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HALLER'S

FIRST LINES

OF

PHYSIOLOGY.

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L. Myers

FIRST LINES OF PHYSIOLOGY,

BY THE CELEBRATED

BARON ALBERTUS HALLER, M.D. &c.

TRANSLATED FROM THE
CORRECT LATIN EDITION
Printed under the INSPECTION of
WILLIAM CULLEN, M.D.

AND COMPARED WITH THE
EDITION publiſhed by H. A. WRISBERG, M.D.
PROFESSOR at GOTTINGEN.

TO WHICH ARE ADDED,
The valuable INDEX originally compoſed for
Dr CULLEN's EDITION;

AND ALL THE
NOTES and ILLUSTRATIONS of PROF. WRISBERG,
now firſt tranſlated into ENGLISH.

IN TWO VOLUMES.

VOL. I.

EDINBURGH:
Printed for CHARLES ELLIOT, EDINBURGH;
And G. G. J. and J. ROBINSON, LONDON.
M.DCC.LXXXVI.

Haller

ADVERTISEMENT.

THE firſt Edition of this Work was publiſhed in 1747. It was deſigned as a correction and improvement of Boerhaave's Inſtitutions, by adding the new diſcoveries of Morgagni, Winſlow, Albinus, Douglas, &c.

IN 1751, another edition was publiſhed; in which ſome things were treated more fully, and others more briefly, than before. The anatomical deſcriptions, particularly, were here abridged; ſome new phyſiological diſcoveries added; and a great number of typographical errors corrected.

A third edition was publiſhed in 1764. Here the author conformed the order of his ſubjects treated of in his Firſt Lines to thoſe of his larger work, and made the number of books contained in both equal; but did not think proper to abridge his Firſt Lines any farther, leſt they ſhould thus have become leſs fit for the purpoſes of a Text-book.

THE demand for this Work ſoon became ſo great, that an edition was printed at Edinburgh in 1766, under the inſpection of the then Profeſſor of the Inſtitutions of Medicine; who had formed the phyſiological part of his lectures upon a ſimilar plan. The greateſt care was taken to have this Edition as exact and free from typographical errors as poſſible; and it was farther improved by the addition of an

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Index, which may be conſidered as an elegant compend of the whole. It was thought proper, however, to retain the erroneous numbers of the paragraphs which had eſcaped in the original editions, for the more eaſy referring from one place to another, and that no confuſion might ariſe from uſing the different editions.

Of the laſt-mentioned valuable Edition the preſent Editor, a few years ago, publiſhed an exact tranſlation, in which all poſſible care had been taken to give the true meaning of the Author, in a plain and eaſy manner: An undertaking to which he was incited by the conſideration, that the tranſlation with which Students had been formerly furniſhed, not only was done from an old edition, exceedingly imperfect in compariſon with the laſt one; but was alſo unneceſſarily extended in the printing to double the ſize of the original, and of courſe proportionably enhanced in the price.

The utility of that undertaking was quickly acknowledged by the favourable reception which it met with, and which has already rendered another impreſſion neceſſary. In preparing this for the preſs, the Editor, ſolicitous to give it every improvement in his power, reſolved to avail himſelf of a new edition of the original recently publiſhed, with Notes and Illuſtrations comprehending the later Diſcoveries, by that eminent phyſiologiſt Profeſſor Wriſberg of Gottingen. Accordingly the following tranſlation has not only been compared with the text of that edition, but all the Notes, about 200 in number, have likewiſe been added. At the ſame time, the former low price has only been increaſed by a very ſmall addition, not at all proportioned to the enlargement of the Work or the expence of the Publiſher.

EDINBURGH, }
Feb. 1786. }

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FIRST LINES

OF

PHYSIOLOGY.

CHAP. I.

Of a FIBRE. CELLULAR TEXTURE.

I. THE human body is compoſed either of fluids or ſolids. Since the fluid parts are of different kinds, we ſhall conſider them afterwards in their moſt proper place; but as the ſolids form the moſt ſimple[1] and true baſis of the body, we ſhall begin with their hiſtory before we enter upon the conſideration of the fluids.

II. The *ſolid* parts of animals and vegetables have this fabric in common, that their elements, or the ſmalleſt parts we can ſee by the fineſt microſcope, are either fibres or an unorganized concrete.

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[1] The firſt elements of all the parts of animal bodies conſiſt of a certain earthy ſubſtance conjoined by a gelatinous matter, and of a little air; from which, by the mediation of the primary fibres, plates and membranes, veſſels and inorganic glue, the chief inſtruments of the body, the bones, muſcles, veſſels, membranes, viſcera, teguments, joints, the whole body, are produced according to the different mixture of the elements, and the various addition of the other parts.

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III. A *fibre*, in general, may be conſidered as reſembling a line made of points, having a moderate breadth; or rather as a ſlender cylinder. And that the more conſtant or permanent parts of which it is compoſed are earth, is demonſtrated from calcination, or long continued putrefaction.

IV. Theſe earthy particles poſſeſs connection and power of coheſion, not from themſelves or a mere contact, but from the intermediate glue placed betwixt them. This we know from the experiments mentioned above (IV.); and from the eaſy experiment, by which a burnt hair, whoſe parts yet hang together, recovers a degree of firmneſs when dipped in water or oil. Alſo the remains of ivory or bone ſhavings, whoſe jelly has been extracted, become friable, like bones, which, by long expoſure to the weather, are converted into a true earth very ready to imbibe water. But even bones rendered friable by having their gluten extracted, will recover their hardneſs when the gluten is reſtored. It is this gluten alone which conſtitutes the more ſimple parts of animals (II).

V. That this glue is compoſed of oil combined with water by the vital attrition in animals, again appears from the chemical analyſis of bones and hair; from the jelly of bones, ivory, and horns; and from the nature of our aliments themſelves. Nor is there any kind of glue that could more powerfully join the parts of animals together; as we experience in fiſh-glue, and that of joiners or cabinet-makers, &c.

VI. Earthy particles, then, (III.) adhering longitudinally, and connected by an intervening coheſive glue (V.), compoſe in the firſt place one of the leaſt or moſt ſimple fibres, ſuch as we underſtand rather from reaſon than ſenſe.

VII.

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[2] The tender embryos in their ovula, the ſoft plants ſtill latent between the cotyledons, ſeem to be mere gluten; which, after a greater quantity of each has been added, acquires ſo great ſtrength, that it is able to ſupport the due figure of the parts. Among the polypi and ſwiming animalcula, the intermediate degrees are very evident.

VII. But the fibres which firſt appear to the ſight, are of two kinds. The firſt kind is lineal; namely, fibres, which have their length conſiderably large in proportion to their breadth; and which, by diſpoſing of the elementary particles in a right line, muſt of courſe lie parallel generally with the contiguous fibres. Examples of ſuch fibres we ſee in the bones, and moſt eaſily in thoſe of a fœtus[3]; and likewiſe in the tendons, ligaments, and muſcles: only, we muſt always remember, that the eye never reaches to the ſmalleſt fibres, but to larger ones made up of the ſmalleſt, and like to them in ſlenderneſs, adjoining in a rectilineal courſe. That theſe are not different from the ſmalleſt fibres, we are perſuaded by the moſt accurate microſcopes of Muyſe and Leewenhoeck; by which the muſcular fibres, divided even to the laſt, appear ſimilar to the larger, till at length they ſeem mere lines.

VIII. The ſecond kind of fibres (VII.) is thoſe in which the breadth is frequently larger than their length. Theſe, when looſely interwoven with each other, are called the *cellular* tunic; though the name *tunic* or *membrane* is on many accounts very improper.

IX. This cellular ſubſtance is made up of an infinite number of little plates or ſcales, which, by their various directions, intercept ſmall cells and web-like ſpaces; and join together all parts of the human body in ſuch a manner as not only to ſuſtain, but to allow them a free and ample motion at the ſame time. But in this web like ſubſtance there is the greateſt diverſity relatively to the proportion betwixt the ſolid parts and intercepted cells, as well as the breadth and ſtrength of the little plates, and the nature of the contained liquor, which is ſometimes more watery, and

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[3] They are very fully perceived in the oſſa bregmatis, frontis, and temporum, if the child has laboured under a hydrocephalus; and alſo in the teeth of larger animals, when the alveoli are as yet ſhut up.

and ſometimes more oily: and likewiſe to the mixture of fibres and threads; of which in ſome parts, as in the coats of the arteries, there is a great number; in other parts, as under the ſkin, ſcarce any.

X. Out of this net-like cellular ſubſtance, compacted by the little plates, concreting and preſſed together by the force of the incumbent muſcles, and diſtending fluids, or by other cauſes, ariſe broad and flat plates or ſkins in various parts of the body, which, being generally diſpoſed in a rectilineal direction, are more properly called *membranes;* or, being convoluted into cones and cylinders, pervaded by a flux of ſome juice or liquors through their cavities, put on the name of *veſſels;* or elſe, being extended round ſome ſpace that is in a plane parallel to itſelf, we call it a *tunic* or coat. But that tunics or coats are formed out of the cellular ſubſtance is proved by ocular inſpection, eſpecially in the aorta, ſkin, pericardium, or dura mater, by maceration; and thus the coats of the muſcles are evidently of a cellular fabric, ſimilar to that of other tunics. The ſame thing is alſo proved from the eaſy change of the dartos, and the nervous membrane of the inteſtines, by inflation into a cellular ſubſtance; from the hard and thick membranes about encyſted tumors, which have their origin only in the cellular texture; and, laſtly, from that membrane, which, being gradually moſt firmly compacted, forms the true ſkin lying under the epidermis, and being thence continued is partly reſolved into the ſubcutaneous cellular texture which is filled with fat.

XI. All the veſſels with which we ſee tunics painted, are an addition to the cellular net-work, and in no-wiſe conſtitute the nature of a membrane, but are ſuperadded to the membrane itſelf, which is firſt formed of the cellular net-like ſubſtance. Betwixt the meſhes or ſpaces of the inteſtinal net-work of veſſels, perfectly well filled by the Ruyſchian art of injection, we ſtill ſee, that the white cellular ſubſtance which remains, greatly exceeds the bulk of the veſſels, although,

though, by their preternatural diſtenſion, they take up more room by filling more of the ſpace[4]. But with regard to membranes compounded of fibres decuſſating or interwoven with each other, I know of none ſuch; unleſs you will take the ligamentary or tendinous fibres for them, which are ſpread over ſome true membrane.

XII. This cellular web-like ſubſtance in the human body is found throughout the whole, namely, where-ever any veſſel or moving muſcularfibre can be traced; and this[5] without the leaſt exception, as far as I know.

XIII. The other elementary ſubſtance of the human body (III.) which cannot be truly called either a fibrous or cellular plate, is a mere glue evaſated and concreted, not within the fibres, but in ſpaces betwixt them. In the bones this extravaſated ſubſtance is manifeſt enough: for you ſee the fibres very diſtinct in the bones of a fœtus, in the intervals between which you perceive the veſſels running; ſo that every bone in the ſkull, on all ſides, reſembles the teeth of a comb. But this fabric is ſo altered in an adult perſon, that the juice being extravaſated in the ſpaces between the fibres and the intervals thus filling up, as happens with the juice of madder, plates are then formed of the teeth above mentioned cemented together[6]. The cartilages ſeem to be ſcarce any thing elſe than this glue concreted.

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[4] Many things ſtill remain which by no means can be referred to the nature of the veſſels. They are very ſucceſsful injections, which can be thrown into the brain, lungs, glandula thyroidea, heart, thymus, kidneys, liver, gall-bladder, inteſtines, teſticle, ſkin, &c.; they leave always a great part of the fibres, in filling which the next age will not be more ſucceſsful than the preſent

[5] This is to be underſtood with ſome limitation. It is true, indeed, of ſeveral parts formed of veſſels, membranes, and fibres, that they can be reſolved by the knife, inflation, maceration, into cellular texture: But the diſſolution of a recent brain, of the cornea, and lens in water; the deſtruction of the epidermis, hairs, and nails; the ſtructure of a great part of the bones and catilages, &c. render it probable, that all the animal parts do not fully conſiſt of cellular texture alone.

[6] The oſſifications and preternatural indurations illuſtrate this parti-

XIV. But here the courſe of nature ſeems to be ſuch, that even the filamentary fibres (III.) are all firſt formed of ſuch a transfuſed glue. And, that the membranous or ſcaly fibres of the cellular ſubſtance (VII.) are thus formed appears from thoſe cellular fibres produced in the thorax from a concreted vapour, which joins the ſurface of the lungs to the pleura; for theſe perfectly reſemble the true and natural cellular ſubſtance. The ſame appears alſo from a compariſon of the fœtus with an adult; for the large ſubcutaneous cellular ſubſtance in a fœtus has in its ſtead a mere jelly interpoſed betwixt the ſkin and muſcles, which laſt we obſerve very firm in a fœtus: from the morbid diſſolution of the membranes of the muſcles into a mere glue: and from a ſimilar change into glue or ſize, made on the ſkin, tendons, and ligaments of animals by means of boiling water. This theory is alſo illuſtrated from clots of coagulated blood, the ſanguineous membranes of Ruyſch, Albinus's membranes formed of mucus, polypus, ſilk, and glue. Laſtly, that the bones themſelves are formed of compacted gluten, is ſhown from diſeaſes, in which the hardeſt bones, by a liquefaction of their gluten, return into cartilages, fleſh, and jelly: ſimilar changes are made on the bones of fiſhes and other animals by Papin's digeſter.

XV. It ſeems, then, that a gelatinous water, like the white of an egg, with a ſmall portion of fine cretaceous earth, firſt runs together into threads, from ſome preſſure, the cauſes of which are not our preſent concern. Such a filament, by the mutual attraction of coheſion, intercepting ſpaces betwixt itſelf and others, helps to form a part of the cellular net-like ſubſtance, after having acquired ſome toughneſs from the neighbouring earthy particles, which remain after an expulſion of the redundant aqueous glue. And in this

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particularly; which are obvious every where, as in the veſſels, and more frequently the aorta, larynx, glandula pinealis, dura mater, &c.

this net-like ſubſtance, wherever a greater preſſure is impoſed on its ſcales or ſides, they turn into fibres and membranes or tunics; and in the bones, laſtly, they concrete with an unorganiſed glue (IV.). Hence, in general, all parts of the body, from the ſofteſt to the hardeſt, ſeem to differ no otherwiſe than in this, that the hardeſt parts have a greater number of the earthy particles more cloſely compacted, with leſs aqueous glue; whilſt in the ſofteſt parts, there is leſs earth and more glue.

CHAP. II.

Of the CELLULAR SUBSTANCE *and its* FAT.

XVI. THE cellular fabric is made up of fibres and plates (IX.), which are neither hollow nor vaſcular, but ſolid; although it is painted by an acceſſion of veſſels. But the principal differences of this fabric are the following[7]. In ſome parts of the body it is open and looſe, being formed of long and diſtant plates; in others it is thin and compact, being made up of ſhort concreted fibres. I find it ſhorteſt betwixt the ſclerotica and choroides of the eye, and betwixt the arachnoides and pia mater of the brain. I alſo find it tender, but more conſpicuous, betwixt every two coats of the inteſtines, ſtomach, bladder, and ureters; in the lungs, where it obtains the name of veſicles; under the pulp of the glans penis; and between the ſmall kernels of the viſcera and glands. It is compoſed of longer fibres, where it is extended over the larger veſſels, under the name of *capſule* or *vagina;* as throughout the viſcera, and particularly the liver and lungs; and is vaſtly firmer

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[7] All the cellular texture may be divided into three claſſes: 1*mo*, The looſe and large, whether it comprehends the fat or not; it for the moſt part connects the larger parts of the body, the muſcles and viſcera: 2*do*, The ſhort and cloſe, conjoining the tunic of the membranous viſcera and the glands: 3*tio*, The confuſed, from which various membranes ariſe, as the nervous coat of the inteſtines and veſſels, pleura, albuginea teſtis, peritonæum, &c.

firmer in the veſſels which go to the head and joints. Its principal uſe is to bind together the contiguous membranes, veſſels, and fibres, in ſuch a manner as to allow them a due or limited motion. But the cellular ſubſtance, ſo far as we have hitherto deſcribed it, hardly ever receives any fat; it is moiſtened by a watery vapour, gelatinous and ſomewhat oily, exhaled out of the arteries, and received again into the veins. The truth of this is eaſily demonſtrable from injections of oil and water, either alone or with fiſh-glue, made in all parts of the body. When this vapour is wanting, the ſmall fibres grow one to another, and the contiguous membranes or plates are cemented into one, with a loſs of their motion.

XVII. The cellular texture is more lax, and formed of plates rather than fibres, where it divides the muſcles and all their fibres, even to the ultimate fibre; where it ſurrounds and ſuſtains the leaſt veſſels with their free motion; and within the cavities of the bones, where it is alſo made up of bony plates with membranous ones intermixed. It is likewiſe very lax under the ſurface of the body, being every where interpoſed betwixt the muſcles and the ſkin; but it is laxeſt of all in the genital parts of the male, which are ſurrounded with very wide cells.

XVIII. Into the empty ſpaces of this cellular texture (XVII.) is poured almoſt every where in the fœtus, firſt a gelly, then a grumous, and laſtly a clotted fat, all under the ſkin, and in its ſmall hollows. It is compoſed of an inſipid inflammable liquid, lighter than water, which in a cold air concretes into a ſolid eſpecially about the kidneys; and in graminivorous animals, in fiſhes, probably alſo in man, while they are alive, it is very nearly fluid, although apt to be indurated. In it, along with the oil, is united an acid ſalt in quantity almoſt equal to the ſixth part of the oil.

XIX. Through this cellular texture the blood-veſſels run and are divided; from the arterial extremities of which the fat is depoſited, and abſorbed by the veins. This paſſage, from the arteries into the adipoſe cells, is ſo free and ſhort, that there muſt needs be very large mouths by which they open, and by which they give admittance to injected mercury, air, water, diſſolved fiſh-glue or jelly, and oil not excepted, which is always very ſluggiſh in paſſing thhrough the veſſels even of living animals. Theſe are ſecreted not by any long ducts, but tranſude on all ſides through the whole extent of the veſſel; inſomuch that, when an artery is filled or injected with water, there is no part of the ſurrounding cellular ſubſtance but what ſwells with the moiſture. The warm fat, during the pulſation of the arteries, eaſily finds out the ſame paſſages. How quickly it is collected appears from the ſpeedy renovation of it, by a returning fatneſs after acute diſeaſes.

XX. But that this fat is abſorbed by the veins, we are taught from the ſudden effects which exerciſe of the muſcles more eſpecially has in conſuming the oil of very fat animals; alſo from the conſumption of our fat in fevers; from the cure of dropſies, where the water transfuſed into the cellular ſubſtance is in a manner abſorbed and thrown out by the inteſtinal tube; and, laſtly, from the tranſuding of water and oil from the venous orifices, when injected by the ſyringe. Are the nerves ſpread out upon the adipoſe cells? It is certain they in moſt parts run through this ſubſtance, and divide into the minuteſt filaments, ſo ſmall that you can no longer trace them by the knife: that they are loſt in it, is not probable[8]; for the fat is both inſenſible and unirritable.

XXI. The intervals betwixt the plates of the cellular membrane, are every where open, and agree in forming one continuous cavity throughout the whole body.

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[8] It is certain that no nerves remain in the fat. In the very ſlender delicate laſhes which pierce the ſoft fat of the orbit, in the infinite diſtributions of the crural and ſciatic nerve through the fat of the femur, &c. the exit of nerves from the fat to other parts is fully apparent.

body[9]. This appears from the inflation which butchers, and likewiſe the ſurgeons of Ethiopia, produce by a wound of the ſkin, and which raiſes the ſkin all over the body; alſo from an emphyſema, in which the air received by a wound of the ſkin, being retained, cauſes a ſwelling throughout the whole ſurface of the body; the paſſage of bodies, put under the ſkin, to a place remote from that at which they entered; the paſſage of pus from an inflamed place to remote ulcers; and, finally, from diſeaſes, in which a watery or ſerous humour is depoſited into all the cells of this net-like ſubſtance throughout the body, and is emptied from them all by a ſingle inciſion. That none of the cellular fabric is excepted from this communication, appears from caſes, wherein the vitreous body of the eye has received the flatus of an emphyſema; and again from diſeaſe, in which the gelatinous ſerum of a dropſy has been found transfuſed even into the cavernous bodies of the penis.

XXII. The great importance and uſe of this cellular ſubſtance in the animal fabric, muſt be evident to all who conſider, that from this part alone proceeds the due firmneſs and ſtability of all the arteries, nerves, and muſcular fibres of the body, and conſequently of all the fleſhy parts and viſcera formed from thence; even the figures of the parts, their proper length, curvatures, cavities, and motions, depend entirely on the cellular texture, which is in ſome places of a lax, in others of a harder fabric; for when it is cut, the parts lengthen and are relaxed: Of this ſubſtance, along with the veſſels, nerves, muſcular and tendinous fibres (of which it alone compoſes a good part), all the viſcera, muſcles, and glands, with their ligaments and capſules, are compoſed. It alone, its various length, tenſion, quantity and proportion, occaſions the difference in the glands and viſcera; and, laſtly, it is it alone which makes the greateſt part of the body itſelf, if indeed the body is not totally formed of ſuch cellular filaments.

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[9] The cellular texture, juſt as the utricular ſubſtance in vegetables, communicates through all the cells of the animal body.

XXIII. This ſubſtance hath a contractile power, different from that of irritability, which, though not demonſtrable by experiments, for the moſt part diſpoſes the cellular fibre to ſhorten itſelf gradually after it has been lengthened. This power, excited by cold, renders the ſkin rigid; raiſes the hairs; draws up the ſcrotum; and, after geſtation[10], reſtores the ſkin of the abdomen and the uterus to their former ſize[11]. The ſame force, by a gentle but continual contraction, promotes the ſecretion both of the fat, the liquors of the ſubcutaneous and other glands, and of pus: in the veins and receptacles, it reſiſts dilatation; which being taken off, it reſtores the part to its former ſize. In the fœtus, this gentle force is among the principal cauſes of the changes that happen to the body.

XXIV. The *uſes* of the fat are various; as to facilitate the motions of the muſcles, in all parts to leſſen their attrition againſt each other, and to prevent a ſtiffneſs or rigidity: it fills up the intermediate ſpaces betwixt the muſcles, with the cavities about many of the viſcera, in ſuch a manner, that it readily yields to their motions, and yet ſupports them when at reſt: it principally conſtitutes the weight of the body; conducts and defends the veſſels: it gives an uniform extenſion to the ſkin; and, ſerving as a cuſhion to eaſe the weight of the body, renders the whole of a comely, agreeable ſhape: probably, by mixing with many of the humours, it abates their acrimony: it has a principal ſhare in forming the bile; and by tranſuding through the cartilaginous incruſtations of the bones, it mixes with the articular liquid, and by re-abſorption it lubricates their fibres: by exhaling through the pores of the ſkin, it reſiſts the inclement drying quality of the air: alſo, by exhaling in a living perſon from the meſentery, meſocolon, omentum, and round the kidneys, it lubricates the ſurfaces of the viſcera with an oily emollient vapour; and, by interpoſing itſelf between their integuments, prevents their concretion.

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[10] And in dropſical caſes, after a cure has been performed.

[11] And reſtores to the mammæ, after ſuckling, their agreeable form and beauty.

XXV. The fat is depoſited into the cells of this ſubſtance by ſleep, reſt of body and mind, and a diminiſhed force of circulation [12]: whence, being collected in too great a quantity, it proves injurious by compreſſing the veins; and, by cauſing too great a reſiſtance to the heart, it makes a perſon ſhort-breathed, and liable to an apoplexy or dropſy. The ſame humour is taken up by the veins; and, being rapidly moved along the arteries, is conſumed by violent exerciſe, venery, watchings, cares of the mind, a ſalivation, diarrhœa, fever, faſting, or ſuppuration. When reſtored to the blood, it increaſes acute diſeaſes, tinges the urine, and forms a part of its ſediment. After a ſudden conſumption of it, it is ſoon renewed again from good juices, or healthy humours: but, in a languid habit, a gelly, inſtead of fat, is depoſited into the cells; and this cauſes the dropſy we call anaſarca, and an external hydrocele or watery ſwelling.

CHAP. III.

Of the VESSELS.

XXVI. THE membranes will be better deſcribed ſingly. There are ſeveral common to the *arteries.* Theſe are long extended cones, whoſe diameters decreaſe as they divide into more numerous branches: but where the arteries run for ſome length, without giving off large branches, their convergency, if any, is not very evident: at length they are cylindrical, or very imperceptibly diminiſhed, when they are called capillaries, and wherever they admit only a ſingle globule; the ſection being every where without exception circular, in a diſtended artery. Where they ſend off large branches, the light or cavity is there ſuddenly diminiſhed, inſomuch that they might be taken for a chain of cylinders, of which every one is narrower than the preceding. If you reckon them cones, then the common baſis of the cone in all arteries is either in the one or the other ventricle of the heart; and the apex of the cone terminates either in the beginning of the veins, or in the beginning of the cylindrical part of the artery, or in the exhaling veſſel, unleſs it is cylindrical. In ſome places they ſeem to diverge or dilate; at leaſt they become there of a large diameter, after they have been filled or diſtended with wax; which poſſibly may ariſe from ſome ſtoppage of the wax, by whoſe impulſe that part of the length of the artery becomes more diſtended than the reſt. Examples of this kind we have in the vertebral artery, at the baſis of the ſkull [13], in the ſplenic artery, in the flexure of the carotid artery, according to Mr Cowper's injections; and, laſtly, unleſs theſe experiments deceive me, in the ſpermatic arteries [14] in all places, likewiſe, where the ramifications between the diameter of the artery is a little increaſed.

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[12] And diſeaſes of the liver, ſince the circulation is remarkable during ſleep, the increaſe of the fat, and the propenſity to dropſy and hepatic affections.

XXVII. There is *no external coat* proper and perpetual to all the arteries; but the office of ſuch a coat is ſupplied to ſome of them by one ſingle external and incumbent integument, which in the thorax is the pleura, and in the abdomen the peritonæum. In the neck, arm, and thigh, a ſort of thicker cellular ſubſtance ſurrounds the arteries. The membrane of the pericardium, which on all ſides ſurrounds the aorta, returns back with the veſſels to the heart. The dura mater imparts a capſule, that ſurrounds the carotid artery as it paſſes out through a hole in the ſkull. But the firſt true external membrane common to the arterial tube in all parts of the body, is the cellular ſubſtance,

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[13] In the baſilar artery, ſo called.

[14] In the artery of the arm a little above the diviſion.

ſtance, which in ſome parts (as in the thorax) we ſee repleniſhed with fat.

XXVIII. This *cellular coat* is, in its external ſurface, of a *more lax* texture, painted with a great many ſmall arteries and veins; and it has nerves runnning thro' its ſubſtance, which are none of the ſmalleſt. There is ſometimes ſo much of this cellular ſubſtance about the artery, as might occaſion one to think it hardly belonged to it as an external coat or lamella, but rather as ſome foreign net-work added to this veſſel. Thus we find it in the arteries of the neck, groins, and ſubclavians; in the meſenteric, cæliac, and hepatic arteries; where it is chiefly interwoven with long fibres. And theſe are the vaginæ or capſules of the arteries, formerly obſerved by ſome eminent anatomiſts [15].

XXIX. As this *cellular coat* advances more inward, and nearer to the light and capacity of the artery, it becomes *more denſe*, ſolid, and is tied more cloſely together by a kind of wool, and may be called the *proper coat* of the artery. That there is no tendinous coat of the arteries diſtinct from this laſt part of the cellular ſubſtance, is evident from maceration, whereby the inner ſtratum of this arterious tunic changes into a cellular fabric [16].

XXX. Within the former, and nearer the light or capacity of the artery, it has *a coat of muſcular fibres*, which are in general imperfect circles: that is to ſay, no fibre any where makes a complete circle round the veſſel; but a number of ſegments conjoined together, with their extremities turned off ſidewiſe, ſeem to form one ring round the artery. Theſe fibres, in the larger arterial trunks, form many ſtrata, appear of

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[15] Theſe additions of ſmaller veſſels to the greater, which ſome people have miſtaken for a peculiar vaſcular tunic, are the more frequent the younger the animal, or if it has laboured under a congeſtion, or died of ſuffocation.

[16] Soluble, according to Albinus's way, almoſt into as many lamellæ as you chooſe, without any evident number or diverſity.

a reddiſh colour, and are remarkably firm and ſolid; but in the ſmaller arteries they are by degrees more difficult to demonſtrate, and ſeem to be wanting in the arteries of ſmall animals. I have never obſerved them to run along the veſſel lengthwiſe. Under theſe membranes, but pretty difficult to demonſtrate, is an exceeding ſhort cellular texture, into which a chalky concreting matter is poured when an artery oſſifies.

XXXI. The *innermoſt coat* of the artery is thin, and finely poliſhed by the influent blood; ſo as to form a ſingle incruſtation that every where lines the fleſhy fibres, which are not very continuous one to the other, and prevents the blood from inſinuating into the ſpaces betwixt them. It is every where ſmooth and without valves; although, from a ſort of mechanical neceſſity, ſometimes certain folds, raiſed into a ſemicircle at the origination of branches, form a projecting eminence; as we ſee at the branches produced by the arch of the aorta. Yet, in arteries of the viſcera, the innermoſt coat is ſofter, lax, wrinkled, and almoſt friable, eſpecially in the ductus arterioſus.

XXXII. The arteries themſelves *have arteries* which are more particularly ſpread through their external cellular coat; and, ſpringing on all ſides from the next adjacent ſmall arterial trunks, from numerous branchy net-works, which are all of them indeed very minute, but plainly appear, even in the fœtus, without injection, to be very numerous. There are alſo *nerves* which deſcend for a long way together through the ſurface of the artery, and at laſt vaniſh in the cellular ſubſtance of the veſſel; of which we have a ſpecimen in the external and internal carotids and arch of the aorta[17]. And from theſe, do not the arteries ſeem to derive a muſcular and convulſive force, very different from that of their ſimple elaſticity? Does not this force ſhow itſelf plainly enough in fevers, faintings, palſy, conſumption, and paſſions of the mind? But the artery is in a manner inſenſible and unirritable [18]; and if it is conſtricted by the application of poiſons, it has this in common with the dead ſkin.

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[17] But this is very remarkable in the nerves, ſo called, molles and cardiaci, that they ſurround the arteries of the head and large veſſels of the heart. In the plexus pulmonalis ariſing from the vagum, the meſenteric from the ſplenic, the facial from the durum, the frontal from the fifth, the femoral from the anterior cruralis,

XXXIII. The *ſections*, or diviſions, of arteries ſhow themſelves with a round light or hollow capacity, becauſe they are elaſtic; and this is the reaſon why, from the ſmall arteries of the teeth, hæmorrhagies are ſometimes fatal. The aorta, indeed, of the thorax and abdomen, the carotids of the neck, and ſome other arteries of the dead body, from their leſſened extenſion, appear ſomewhat flat or depreſſed; but their round figure, or circular ſection, is every where reſtored by injection. *Their elaſticity* is alſo evident in that powerful compreſſure, which a ſegment of a large artery makes upon the finger that diſtends it, and which is much ſtronger in a dead than in a living body. In the living body, indeed, this force yields to that of the heart; but inſtantly recovers itſelf when the heart is relaxed, and reſtores the artery to its former diameter; and this makes the *pulſe*, whoſe full explication ought to be preceded by a hiſtory of the heart: at preſent it may ſuffice to ſay, that all the arteries have this pulſation, although the ſyſtole and diaſtole thereof can be perceived by the finger, only in the larger, not in the ſmaller ones naturally; and in the ultimate inflection of the arteries, the pulſe totally vaniſhes; but, by an increaſed motion of the blood, even the leſſer arteries make a violent pulſation, as we ſee in an inflammation [19]. Theſe veſſels ſtrongly contract lengthwiſe, and are rendered ſhorter on diſſection.

XXXIV.

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cruralis, it is manifeſt that they accompany the veſſels, and ſpread out an infinite number of branches through their tunics.

[18] This opinion of the irritability of the veſſels has been limited from later experiments.

[19] Or on preſſure depending on an external cauſe.

XXXIV. The *ſtrength* of the arteries is conſiderable enough: but as the denſe hard net-work of the outer cellular coat refuſes to yield to a diſtending force, it breaks without much difficulty, almoſt eaſier than the coats of the veins; and from thence ariſe aneuriſms. But, in general, the trunks are, in all parts of the body, weaker, and the branches ſtronger, in their coats; whence the impulſe of the blood may exert a conſiderable effect upon the former, but leaſt of all on thoſe of the limbs. From hence it is, that aneuriſms are moſt frequently formed near the heart; for, in the lower extremities, the ſtrength of the arteries, and of the veins too, is much increaſed, as well as in the ſecreting organs.

XXXV. With regard to the *courſe and general diſtribution* of the arteries, nature has every where diſperſed them through the whole animal body, except in a few membranes. But ſhe hath diſpoſed of the trunks every where in places of ſafety; becauſe wounds cannot happen to the ſmaller of them without danger, nor to the larger without loſs of life. The ſkin is ſpread with numerous ſhort and ſmall arterial trunks; but the larger ones, defended by the ſkin and muſcles, creep along near the bones. In general, the arteries are in proportion to the parts of the body to which they are ſent. The largeſt go to the ſecretory organs, the brain, and ſpleen; the leſſer ones to the muſcular parts.

XXXVI. The proportion of the light or cavity of the artery to its ſolid part is not every where the ſame, nor is it conſtant even in the ſame artery. This proportion, in the firſt place, is leaſt of all at the heart, and increaſes as the arteries remove farther from it. Secondly, in a full-fed plethoric animal, whoſe blood paſſes freely, and with great force thro' its arteries, the proportion of the ſolid parts of theſe veſſels is leſs than in a famiſhed extenuated creature, whoſe blood hath a feeble motion.

XXXVII. From the trunks of all the arteries branches are ſent forth, and from theſe again proceed leſſer twigs by a numerous diviſion, of which you can ſcarce find the end, though you may perhaps count twenty ſubdiviſions of this kind. Here the lights or ſections of any two branches taken together, always exceed the light of the trunk from whence they come, in nearly a ſeſquilateral proportion, or as one and a half to one, or ſomewhat leſs. Alſo every trunk juſt above its diviſion is ſomewhat broader or more expanded. The angles, at which the branches go out from their trunks, are generally acute, either half right angles or nearly ſo; to the forming of which angles, as we ſee in mechanics, there is required the longeſt projection. Inſtances of their going off at right angles, or nearly ſo, we have in the lumbal or intercoſtal arteries; of their going off in a retrogade or reflected courſe, we have one inſtance in the coronaries of the heart, and another inſtance in the ſpinal arteries, which are produced by the vertebrals. But, generally ſpeaking, thoſe which are eſteemed retrogade or reflexed, were ſent off, at their origin, in acute angles; ſuch as the aſcending artery of the pharynx, the deſcending one of the palate, the umbilical mammary arteries, and the nutritious ones of the large bones. Laſtly, we often obſerve large branches ariſing under leſſer angles, and ſmaller ones under greater angles: but it is rarely that we obſerve two arteries of a large diameter run together into one trunk. An example of this, however, we have in that artery which is formed out of the vertebrals: in the ſmaller ones it is frequent, as in both the ſpinal arteries, and that of the ſincipital foramen. In many parts, the arteries have repeated alternate undulations or flexures, as they run on in a ſpiral courſe, wherein we ſee their diameter often conſiderably enlarged, as in the large inteſtines, womb, face, ſpleen, lips, and iris. Even the ſtraight arteries in other places, if too much diſtended, fall into ſerpentine flexures. Sometimes they are ſuddenly twiſted into a kind of circles, as the carotids under the mamillary proceſs.

XXXVIII. The artertes are frequently conjoined by intermediate *branches*, in ſuch a manner, that the twig of ſome certain artery ſhall run to meet one of the ſame kind from another neighbouring artery, and, by joining together with that, form one trunk. Inſtances of this kind we have among the large trunks in the inteſtines, among the middling ones in the kidneys, womb, &c. and among the ſmaller in all parts of the body; inſomuch that there is no part of the human body, wherein the neighbouring arterial trunks, whether of the ſame or of different denominations, do not form anaſtomoſes or joinings one to the other by intermediate branches. Of rings diverging laterally from the arteries, and returning into themſelves, we have inſtances in the eye and brain. The extremities of the arteries, which are either cylindrical or nearly ſo, ſend off ſmaller branches, which, for their extent, are more numerous and generally diſpoſed like a net; ſo that each branch, by its ſmaller twigs, forms anaſtomoſes with thoſe of its neighbouring branches: and thus we find it in all membranes. By this means it happens, that, though the paſſage from the heart to any part of an artery is obſtructed, the blood may nevertheleſs flow through the neighbouring arteries into all the branches of the obſtructed one. Thus a gangrene or languor of the part is very ſtrongly prevented, and the obſtruction is more eaſily reſolved by the repulſion of the obſtacle into the larger part of the trunk.

XXXIX. Laſtly, one of the leaſt arteries is either changed by a continuation of its canal into a vein, in ſuch a manner, that the ultimate little artery, which is generally reflected, having ſurpaſſed the angle of its reflection, becomes now a ſmall vein; or elſe a branch, ſent out at right angles from the artery, is inſerted under a like angle into the branch of a ſmall vein. Both theſe kinds of mechaniſm are demonſtrated to us by the microſcope, and the eaſy return of injections through the veins into the arteries. And theſe vaſcules we ſee ſometimes large enough to receive only one, and ſometimes ſeveral blood-globules at a time. A large artery is never obſerved to open into a vein.

XL. *In the viſcera*, we find the ſmall arteries diſpoſed not ſo much in net-works as in a different fabricature, wherein the ſmall branches deſcend very thick, or in cluſters, parallel to the trunk, ſo as to reſemble bruſh-pencils, a variety of little trees or buſhes, ſmall ſerpents, or threads, according to the various diſpoſition of the parts.

XLI. Sometimes the arteries end in another manner, namely, by being converted into veſſels of the ſmaller kinds. Theſe are ſometimes continuous to the arteries and real arterial trunks, as will be obſerved in the ophthalmic artery, upon tracing the arteries of the tunica choroides, or the colourleſs ones of the circle of the uvea and iris. That a net-work of pellucid arteries is continuous with the red branches of the ophthalmic one, is evident from inflammations, and the redneſs of the parts when relaxed by vapour or by cupping; from repletion, and the microſcopical experiments of Lieberkuhnius upon frogs, in which colourleſs globules were ſeen to paſs from a red artery into a lateral veſſel. In a fabric of this kind the red blood is eaſily forced into the ſmaller veſſels.

XLII. In other places the ſmaller veſſels ſeem to proceed laterally as branches from the trunks of the leaſt ſanguineous arteries, and are drawn out into trunks ſtill ſmaller. Theſe are called *excretory ducts*[20]. It is with difficulty that theſe veſſels are filled with red blood; of this, however, we have examples in the kidneys, the liver, and breaſts. Indeed the blood, when vitiated, penetrates the excretory ducts of the whole body, even without hurting the veſſels; nor is that aberration found to be productive of any evil conſequence after the diſorder of the blood is cured.

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[20] I would rather call them ſecretory; for they properly carry a liquor to be ſecreted from the blood to the ways and places of excretion. I have almoſt always ſeen mercury, diſſolved fiſh-glue, or turpentine, when injected into the arteries after tying the veins, flow from the biliary, ſalival, urinary, and lactiferous ducts; but there is at the ſame time an eaſy paſſage of pure blood through the ſame canals.

XLIII. Another termination of the arterial extremities is *into the exhaling veſſels;* and this is a manner of their ending very frequently to be obſerved in all parts of the body. The whole ſkin, all membranes of the human body, which form any cloſe cavity, all the ventricles of the brain, the anterior and poſterior chambers of the eyes, all the adipoſe cells and pulmonary veſicles, the whole cavity of the ſtomach and inteſtinal tube, through which the air has a paſſage, are all of them repleniſhed with exhaling arteries of this kind. Theſe emit a thin, watery, gelatinous humour, which, being collected together by ſtanding, ſometimes makes no inconſiderable quantity; and, particularly by diſeaſe or death, is converted into a watery, but coagulable lymph. The truth of this is eaſily demonſtrable from the watery ſweat that enſues after injecting the arteries with that liquor warm. In ſome places, indeed, they exhale not a thin vapour, but blood itſelf, as we ſee in the heart, the cellular fabric of the penis, urethra, clitoris, and nipple of the female breaſt; in all which the blood itſelf is naturally poured out. Does not every ſecretion, that is made in true glands or hollow cryptæ, bear ſome analogy to this exhaling fabric?

XLIV. Whether or no, in all parts of the human body, do the pellucid veſſels, ariſing from the ſanguine ones, and carrying a humour thinner than blood, again ſend out ſmaller veſſels, to be ſubdivided into ſtill leſſer orders? We ſeem, indeed, not to want examples of this in the manner propoſed to us by the moſt celebrated profeſſors[21]. That the aqueous humour

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[21] I have ſeen beyond all diſpute, a new riſe of blood-veſſels, where before they were inviſible. This is very clear in the chemoſis; but I have alſo obſerved a net-work of veſſels on the inner ſurface of the dura meninges in a woman, who had a very large glandula

humour is ſeparated by very fine veſſels, generated from the colourleſs arteries of the iris, is very probable. That the red-coloured veſſels in the cortical ſubſtance of the brain, ſeparate a juice pervading the medullary ſubſtance, by the intermedium of another order of veſſels, we are almoſt certain. And the like we are perſuaded from an eryſipelas or yellow inflammation, ariſing from the yellow or ſerous globules impacted into ſmaller veſſels.

XLV. It may then be aſked, if there are not yellow arterious veſſels of a ſecond order, which ſend off lymphatic ones of a third order, from whence by degrees ſtill leſſer kinds of veſſels branch out? Such a fabric does not ſeem agreeable to the very eaſy tranſition that is made by the blood, mercury, or wax, into the exhaling and perſpiratory veſſels, or into the uriniferous tubuli, with the adipoſe and pulmonary cells; nor is it very difficult for the blood to ſtray into the lactiferous, lymphatic and lachrymal ducts, whither it ſhould ſeem not able to penetrate, if it went through any other intermediate vaſcular ſyſtem ſmaller than the blood-globules, which make the ſame journey. Nor can it be admitted, from the great retardation, which the humours muſt, in a third order of veſſels, meet with from this mechaniſm, and which is continually to increaſe in proportion to their diminiſhed ſize.

XLVI. The Veins, in many particulars, reſemble the arteries[22]. There are ſix, of which two anſwer to the aorta, and the remaining four to the pulmonary artery. Their baſis is in the ventricles of the heart, and their apices in the extremity of each branch, through all parts of the body, excepting one inſtance in

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glandula thyroidea, which by compreſſing the jugular veins obſtructed the regreſs of the blood from the cranium: the ſame thing happens upon the lungs, liver, and other viſcera.

[22] We ought to count ſeven trunks of veins; for the vena portarum, conducting its contents through ſo many windings, at length pours them into the venæ hepaticæ: ſo that it is altogether to be reckoned a very ſingular trunk.

in the liver. And, in a great number of parts they run parallel with the arteries, one by the ſide of the other; but yet they differ from the arteries in various reſpects.

XLVII. The fabric of the veins is ſlender, every where ſmooth, difficultly ſeparable into diſtinct coats or membranes, like the arteries; and the cellular texture ſurrounding this fabric is very eaſily diſtended. This fabric, both above and below the heart, is ſurrounded, except in one place, with muſcular fibres. Every where, however, it is lax like the cellular texture of the arteries by which they are joined to the other parts of the body. Notwithſtanding this ſlender fabric, the veins are every where ſufficiently firm, and do not eaſily burſt with inflated air; being, in moſt inſtances, ſtronger than the arteries themſelves. But they burſt much more eaſily in living than in dead animals, as appears from morbid inſtances in the arm, face, leg, thigh, &c.[23] Nor do they ſupport themſelves like cylinders after being divided, but they collapſe together, ſo as to make their light or capacity appear like a ſlit; except they are ſuſtained and hindered from thus collapſing by ſome ſtronger cellular ſubſtance placed round them, as we ſee in the liver and womb. They are but ſlightly irritable, unleſs the ſtimulus be of the chemical or more acrid claſſes; for, in that caſe, they contract themſelves with a convulſive force greater than that of the arteries. They have no pulſation, if we may truſt all accounts, unleſs the venous channel is ſomewhere obſtructed; or when, in dying people, the blood is thrown back again from the right auricle into the deſcending and aſcending cava, or when falling back from the brain.

XLVIII. The veins are much larger than their correſponding arteries, having the ſquare of their diameter often double or triple, and almoſt quadruple; as near as the emulgents and veſſels of the kidneys. In general, however, the diameter of the veins is

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[23] I know very lamentable caſes of ruptured varices in different places in child-birth.

to that of the arteries as nine to four; yet the capacity of the capillary veins but little exceeds that of the arteries which accompany them. They differ likewiſe from the arteries in their diviſion, having more numerous trunks and branches[24]; for to one artery in the limbs, we uſually meet with two veins. The larger veins are alſo branched in a more net-like diſpoſition, by forming more frequent anaſtomoſes one with another; for not only the ſmaller branches, but even the larger trunks, of the veins, are conjoined one to the other within its neighbourhood, upper with lower, and right with left, by apparent inlets or inoſculations. They affect to run near the ſurface of the body; and through the limbs, neck, and head: they run a long way covered with little more than the bare ſkin, which is a circumſtance we very rarely obſerve in arteries; and, for the ſame reaſon, they often go out in their courſe, to a conſiderable diſtance from the arteries. For, in this caſe, the veins follow the ſurface of the parts next the ſkin, without their correſponding artery, which, in the mean time, deſcends to a conſiderable depth, attended in its courſe by ſome ſmaller venous branch. In the ſmaller branches of the veſſels, where they make net-like diſpoſitions in the membranes and the internal fabric of the viſcera, the veins and arteries commonly run contiguous one to the other; but here the veins have generally a leſs ſerpentine or inflected courſe.

XLIX. In the larger ſanguineous veins, little valves are found in great plenty. The innermoſt membrane of the vein, being double, riſes into the cavity of the veſſel like a curtain, ſtretching itſelf farther along the vein every way, ſo as to form what may be called a kind of little horns; but the baſis, which is the part that ſuſtains the weight of the blood, is ſtrongeſt, and grows out of the vein in the ſhape of a circular ſegment. Theſe, joined with the ſide of the proceeding vein, intercept a ſpace of which the outer ſide is the vein itſelf, and the inner the valve, which, by its convexity, ſtands out within the bore of the vein; ſo that the parabolic ſpace or hollow mouth of the valves always looks towards the heart: they are found in all the ſubcutaneous veins of the limbs, in thoſe of the neck, face, tongue, and in the veins of the penis: at the origin of the larger branches there are two, three, four, and ſometimes five of them together, while in their ſmaller branches they are only ſingle. There are none of theſe valves in the deep-running veins of the viſcera; and, therefore, none in thoſe of the brain, lungs, heart or liver, or through the whole ſyſtem of the vena portarum[25], nor in the kidneys or womb (except one or two valves in the ſpermatic vein); nor, laſtly, are there any in thoſe ſmaller blood-veins, which are of a leſs diameter than the twelfth part of an inch. Sometimes, though rarely, they are found in the vena azygos[26], and at the mouths of the hepatic and renal veins: there I have ſeveral times obſerved a ſort of wrinkles in the place of valves. In the ſmaller venous branches there are a ſet of long, ſharp-pointed or parabolical valves, of a more extended figure as the vein is ſmaller: and theſe make a greater reſiſtance than the larger valves, to hinder the blood from returning back upon the parts.

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[24] There are examples almoſt every where in the body, particularly in the ſmaller veins; but even in the larger they are to be found, as the external jugular, vena portarum, azygos, cephalic and baſilic, magna ſaphena, with which no arteries correſpond.

L. The veins have their origin, as we ſaid before, from the terminations of the arteries. They ſometimes ariſe by a continuation from the inſerted branches, or from a reflection of recurved trunks of the ſmalleſt arteries[27]. Others again are either continued from veins leſs than thoſe which carry blood, or elſe receive additions and roots from them; as we ſee, for inſtance, in the lymphatic veins of the thoracic duct. Others of a bibulous kind take their origin from the abſorbing veins, that are diſperſed all over the ſurface of the body, as in the chambers of the eyes, the cavities of the inteſtines, bladder, womb, breaſt, peritonæum, pericardium, and ventricles of the brain. From theſe a watery ſweat iſſues, by injecting the venous trunks with that kind of liquor, which may be eaſily imitated throughout the whole human body: hence water, jelly, or oil[28], diſtil from the vena portarum into the cavity of the inteſtines; hence alſo water, injected into the abdomen of a living animal, quickly vaniſhes: but of theſe things we ſhall ſpeak more largely in a proper place.

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[25] In the ſyſtem of the vena portarum of many quadrupeds, I have found numerous valves; and on that account was unable to fill the veins of the inteſtines, as in man, through the trunk of the vena portarum.

[26] Not before the ramifications of the azygos touched the muſcles; for they commonly there reſiſted my injection.

[27] It is proved from microſcopical obſervations on fiſhes, from the

LI. From the former thoſe veins do not much differ, which, ariſing in all parts of the cellular membrane, return thin vapours, dropſical waters, diſſolved fat, or extravaſated and corrupting blood, and the poiſon of opium introduced into the cellular texture, again into the maſs of the blood; or which reabſorb and return the blood itſelf from the cellular fabric of the penis, clitoris, or nipples of the breaſts after coition. And that inhaling veins of this kind open into all the glands, is highly probable; where, by abſorbing the thinner humour, they leave the remaining maſs of a thicker conſiſtence; of which we have inſtances in bile, ſemen, mucus, &c.

LII. That there are veins of a *ſmaller claſs*, but reſembling thoſe which convey blood, appears from the ſame experiments which demonſtrate the pellucid arteries: thus in the iris of the eye there are ſmall veins, and not a few in the adnata tunica of that organ;

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the very eaſy paſſage of the blood from the arteries into the veins, and ſucceſsful injections of the veins through the arteries, that by far the greateſt part of the veins ariſes from the arteries without any body intervening.

[28] No liquid has a more eaſy tranſit from the veins into the inteſtines than mercury has, whoſe effects I have often enough experienced.

gan; nor is it to be doubted that, in a healthy body, ſmall pellucid veins[29] may be found in the vitreous body of the eye itſelf.

LIII. But, in moſt parts of the human body, are found other veins[30], full of a reddiſh, yellowiſh, or almoſt pellucid liquor, coagulable by heat; which veins, being formed of very tender coats, have a degree of irritability from any chemical or very acrid ſtimulus. They have very frequent valves or partitions, which make them ſeem in thoſe places jointed or knotted like a reed when they are turgid; theſe, by degrees, meeting together, either all or moſt part of them empty their contents into the thoracic duct. They ariſe from the cellular texture throughout the whole body, as I long ago learned concerning the lactiferous veſſels of the breaſts, the vaſa efferentia of the teſticles, the lymphatics which originate from the meſenteric glands; and as is now ſhown to be the caſe with the lymphatic veſſels of the teſticles, ſpleen, and other parts. From analogy, eſpecially from hydropical appearances, it is very probable that they ariſe likewiſe from the large cavities of the body; nor is it improbable that this kind of veſſels receive a thin humour from veins of the ſmalleſt ſize. But all the lymphatics, in their courſe, meet together in a peculiar kind of conglobate glands, into which they enter; and, from the ſhape of veins, becoming arterial, or like converging cones, they divide into ſmall branches, and then proceed to meet together again in other little trunks.

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[29] I have obſerved both from anatomical injections, and from inflammation, thoſe numerous veins of the capſule of the lens, and of the vitreous humour.

[30] A new genus of veſſels, to be diſtinguiſhed from others by the name of *abſorbents*, undoubtedly pervades the whole body, whoſe knowledge, ſtudy, and accurate inveſtigation, throws light upon the whole ſcope of medicine. It is out of all doubt, that it is different from the ſanguiferous veins, nor can they be filled through the ſame; and if we take into account all the experiments which have been ſet on foot by Jolyff, Rudbeck, Bartholin, Nuck, Salzman, Hunter, Monro, Meckel, Sograf, Hewſon, and Walter, for the ſake of elucidating that ſyſtem, a double genus of veſſels hence ariſes, in regard to the liquor they convey, viz. the lacteal, originating from the inteſtines, its courſe being directed through the meſentery towards the recptacle of the chyle; the other, the lymphatic, coming from all the reſt of the body and its cells, and joined with the former in many places.

LIV. Theſe glands themſelves are, as it were, only ſmall clues [31] of lymphatic veſſels connected by a cellular texture, into which the arterial liquor exſudes, and is conveyed from the ſame by the veſſels which ſerve to bring back the lymph. They are covered with a continuous membrane almoſt of an oval ſhape; and this is the caſe, whether they are ſingle or heaped together: and they chiefly follow the courſe of the veins through the whole trunk of the body, even to the tops of the limbs; running along the jugular and ſubclavian [32] veins, the vena cava ſuperior, the aſpera arteria, gullet, lumbal vena cava, vena porta, the iliac, hypogaſtric, and crural veins, the veins of the thigh, and likewiſe the veſſels of the ſtomach, ſpleen, meſentery, and meſocolon.

LV. They are found ſeated on all the ſurfaces of the viſcera, in the thorax and abdomen; but are more eaſily diſcovered in brutes. They run through the lower part of the face, muſcles of the tongue, the adjacent parts of the neck, and thoſe parts of the upper limbs which are neareſt the trunk, as far as the bending of the elbow [33]; throughout the whole length of the mediaſtinum, before and behind, and wherever we find conglobate glandules, either in the neck or thorax: the lymphatic veins are alſo ſpread through the whole lumbal region that is contiguous to the aorta, the meſocolon and pelvis, veſſels and ſurface of the teſticle; and in the lower limbs, wherever they are ſupplied with conglobate glandules, even to the knees. Whether they extend further into other parts throughout the whole body, or through the brain, eyes, hands, feet, back, fore part of the peritonæum, &c. remains as yet undetermined; at leaſt, there are not examples enough in the human body upon which one can depend to evince the truth of their exiſtence. But they are every where to be found upon the ſurfaces of the viſcera. They are almoſt every where collected into bundles not far from the large blood-veſſels. Thoſe from the inferior limbs, pelvis, and loins, run into one duct, which is joined by another bundle coming from the liver, ſpleen, and ſtomach; and that trunk at length becomes the thoracic duct. The ſuperior veſſels, from the whole extent of the breaſt, the head, and ſuperior limbs, empty themſelves into the ſame duct towards its upper extremity. They ſeem, however, likewiſe to terminate in the red veins[34].

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[31] It is now certain, from the experiments of Hewſon and my own, that the lymphatic and lacteal glands do not, as has been imagined, conſiſt of cellular texture, as if reſembling a ſponge, into whoſe cells the other lymphatic veſſels might empty their liquors, and others again might take up the ſame; but that they are a combination, as it were, and conjunction of ſeveral lymphatic veſſels; many of which are indeed divided into leſs branches, from which larger branches ariſe: which ſtructure, however, by no means interrupts the ſeries, nor prevents the fluids from moving through the gland.

[32] New ones have been deſcribed by Camper in the interior ſurface of the ſternum, ſituated near the mammary veſſels, very neceſſary to be known for underſtanding cancers of the mammæ.

[33] As the preſence of abſorbent veſſels has been demonſtrated, both lymphatic and lacteal, in many claſſes of animals, as the birds, viz.

LVI. Of what ſervice theſe glands are to the lymphatic veſſels is not well known. In the fœtus they are

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viz. the gooſe, Indian cock; amphibia, viz. the tortoiſe; and likewiſe in fiſhes; ſo I have ſeen them in quadrupeds and man, in the hands and feet, the brain and eye. It is therefore probable, that ſcarce any part exiſts, quite devoid of them: many are found always upon the viſcera, as in the liver, ſpleen, kidneys, mammæ, lungs, ovaria, uterus, teſticles, &c. nor are they wanting in the cavities of the joints.

[34] From my own trials, at leaſt, I am certain, that the lymphatic veſſels in many places pour their contents into the neighbouring veins; for from the inguinal and lumbar plexus, I have evidently ſeen conſiderable branches ſent to the crural vein, and the vena cava itſelf, and from the thoracic duct to the azygos: but experiments ſhould be repeated, before we aſſert a thing to be univerſally fact.

are ſwelled with a milky liquor, as alſo the thymus and glandulæ renales; but it is not certain whether this juice is poured out into the cellular texture. It is rendered probable by late experiments, that ſome kind of juice is prepared in theſe glands, which is mixed with the lymph; and that a thin humour, injected into the arteries, likewiſe enters the lymphatic veſſels[35]. By age, this juice vaniſhes; and the glands themſelves, being dried up, almoſt totally diſappear. A very ſudden ſcirrhus happening to theſe glands ſeems to be the cauſe of their decay.

LVII. The *valves* of theſe pellucid veſſels (LIII.) are compoſed of two ſemicircular membranes, which give way to the fluid that goes towards the larger trunks; ſo that, by applying themſelves cloſe to the ſides of the veſſel, they leave a free light or capacity through it. But the ſame valves, if the contained liquor is preſſed back towards the ſmaller branches of the veſſel, being filled out therewith, ſwell or expand, ſo as to ſhut up the light of the canal.

CHAP. IV.

Of the CIRCULATION *or* MOTION *of the* BLOOD *through the Arteries and Veins.*

LVIII. THE arteries and veins, which we have hitherto deſcribed, contain either blood or lymph. The red blood, whoſe nature we ſhall explain when we come to treat of ſecretion, fills the arteries and veins commonly known, which we call *red*, or thoſe of the firſt order, and which have their origin in the heart. Theſe it ſo fills in a living perſon, that at ſome times they are very looſely and imperfectly

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[35] I have ſometimes accidentally filled conſiderable plexus of the lymphatic veſſels in the liver, lungs, and ovaria, through the arteries; but I muſt confeſs, that before this happen, the liquor ſhould be far more frequently poured out from the veſſels into the cellular texture than into the canals of the lymph. But frequently, in dropſical perſons, I have ſeen the lymphatic veſſels ſufficiently large, to equal a quill's thickneſs in a dropſical ovarium.

perfectly diſtended by it, and at other times they are rendered very full and turgid. After death, the veins are found fuller of blood than the arteries; but ſometimes, when the perſon has been dead a conſiderable time, the ſmall veins have been found diſtended with air. But the arteries of a dead body commonly contain only a ſmall quantity of blood.

LIX. This diſtending blood, then, is rapidly moved through all the veſſels of a living body. The truth of which is demonſtrated to us from wounds, by which the patient ſoon expires from the loſs of ſo much blood as was neceſſary for the maintenance of life; which loſs of blood happens almoſt inſtantly from the larger arteries, and ſometimes very ſuddenly from the ſmaller ones: but from the veins, unleſs they are ſome of the largeſt, this loſs of blood is more ſlow and difficult; yet are there not wanting inſtances of fatal hemorrhagies from wounds of the veins, in the inner corners of the eyes, and thoſe under the tongue[36]. Experiments made upon living animals ſufficiently evidence the impulſe and rapidity with which the blood is moved, particularly through the arteries[37]. In the larger trunks, it runs moſt ſwiftly; but in the leaſt of them, ſomewhat ſlower. And, in the larger veins, the blood's celerity is leſs than in the arterial trunks, in the ſame proportion as the lights or ſections of the arteries are leſs than thoſe of the veins, i. e. twice or almoſt thrice ſlower. Another argument of the circulation, is the compreſſure and relaxation of a vein, whereby the motion of the blood is promoted from one valve to another. This motion of the blood is, in the veins, uniform or equable enough; but in the arteries it is alternately greater when the veſſel is more dilated, and leſs when it is contracted. This is proved by ocular inſpection in living animals.

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[36] There are likewiſe examples of hemorrhagies from the frontal from anger, and likewiſe from the ſmall ſaphena in a gravid woman, which threatened death, in whom I tried the opening of the veins.

[37] The height to which blood from cut carotids aſcended, according to Hales's calculation, I ſaw confirmed in robuſt men who had been ſentenced to die, to wit, about ſeven feet; with this difference, however, that in two examples the blood ſprung higher from the vertebral than from the carotid veins.

LX. That the motion which the blood deſcribes, is a courſe through the ſanguineous arteries into the veins, is diſcovered from experience. For, firſt, it is certain, that all the arteries and veins communicate or open one into the other; becauſe often, from one, and that a ſmall artery, all the blood ſhall run even until death, and make all the fleſh exceedingly pale; and this not only out of the wounded limb, but from the whole body. Of ſuch fatal examples we have a number from an inner artery of the noſe, from the gums, a finger, tooth, cutaneous pore enlarged, from the lachrymal point, from the wound of cupping on the ſkin, and even the bite of a leech. There are, therefore, of courſe, open ways, by which the blood ſpeedily flows from the venous into the arterial ſyſtem.

LXI. That the blood, again, in the arteries, flows from the heart toward the extreme parts of the body, is proved by the microſcope, and by a ligature on the artery of a living animal[38]. For whatevever artery ſhall be ſtopped by a ligature, the ſwelling enſues in that part betwixt the heart and the ligature, whilſt the other part is emptied beyond the ligature, which is the part of the artery more remote from the heart: neither has it there any pulſation; nor if it be there wounded, will it yield any blood. The ſame effects, which we ſee follow from a ligature, are likewiſe often produced by diſeaſe; as when ſome tumor, by compreſſure, or an aneuriſm, intercepts the blood's motion from the heart. Experiments of this kind have been made on moſt of the arteries; anaſtomoſes, however, or the blood flowing through a neighbour-

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[38] Among the arguments which evince the real direction of the blood from the heart into the arteries, the fabric, mechaniſm, and proportion of the ſemilunar valves between each artery, and the ventricles in all quadrupeds, by no means ought to have been overlooked; for it is abſolutely hindered by them from relapſing from the arteries to the heart.

ing branch, or the retroceſſion of the blood in a dying animal, form exceptions to this rule.

LXII. But of the courſe or motion of the venous blood, it has been always more doubted; almoſt all the ancients have been perſuaded, that the blood in the veins flowed through them, either from the heart or from the liver, to all parts of the body. Very few of them have known that this was an error. Several of them have, indeed, acknowledged it to be falſe in the pulmonary vein. But that the blood did not move from the heart in the vena cava was known to ſtill fewer anatomiſts of the ancients; only to Andreas Cæſalpinus by chance, and (from an extraordinary accident) to Veſalius.

LXIII. Dr William Harvey is the firſt who experimentally aſſerted the motion of the blood returning in the veins to the heart, in ſuch a manner as to render the whole intelligible, and leave no room to doubt of it. And, firſt, *the valves of the veins* lead us to this truth: for the common uſe or office of theſe valves is, to determine the preſſure that is given from any quarter upon the veins, towards the heart, by allowing no opportunity to the venous blood that has once entered the trunk, which they intercept, to flow back to the branches. For, ſince the covering ſpaces of the valves open upwards towards the heart, the blood enters and expands them. Thus thoſe parts of the valves which project freely into the cavity of the vein, approach towards the axis, until the oppoſite ſides by meeting together ſhut up the tube. This we know from inflations, ligatures, and injections of the veins; for you never can force a liquor eaſily into the veins by propelling it againſt their valves. They do not, indeed, every where ſhut up the whole cavity of the veins; but where they ſhut not cloſe, they always intercept the greateſt part of the light.

LXIV. Another office of the valves in the veins ſeems to be for ſuſtaining the weight of the blood, that its upper columns may not gravitate upon the lower; nor the blood, flowing through the trunks, make too great a reſiſtance againſt that which follows it through the branches. For if, from the ſlower motion of the blood, its weight or preſſure ſhall, in any part, much exceed the impulſe that drives it on, ſo as to cauſe ſome part of the column to deſcend by its weight; it is, in that caſe, immediately catched, and ſuſtained in its relapſe by the next adjacent valve, which hinders it from urging againſt the next ſucceeding column, and affords time and opportunity for ſome contiguous muſcle, by its preſſure or concuſſion to propel the ſaid column. And this is the reaſon why valves are placed in the veins of the limbs and neck; in which parts they are both more numerous and more robuſt than elſewhere. And this is the cauſe of varices, when the blood, entering the hollow valves, urges their ſolid convexity downwards, and makes the vein dilate in that part. Likewiſe, in muſcular action, the valves are the cauſe of the whole effect of the preſſure which the veins ſuſtain, forwarding the blood in its due courſe towards the heart.

LXV. Moreover, the valves, placed in the right ventricle *of the heart*, have ſuch a fabric, as we ſhall hereafter ſee, that they freely permit blood, air, or wax, to paſs from the venous trunks of the cava into the heart, but deny any reflux from the heart into the veins.

LXVI. Again, *ligatures*, in a living perſon, may make the thing more evident. When the veins of the limbs are tied, either by deſign or accident, with the limb itſelf about the hams, arms, ancles, or wriſts, the limb below the ligature ſwells, the veins fill and diſtend themſelves, and when opened make a free diſcharge of blood: but at the ſame time nothing of this kind happens above the ligature, nor are any of the veins to be ſeen there. The ſame phenomenon happens when the veins are compreſſed by ſwelled and ſcirrhous glandules in the viſcera; and from polypuſes the veins are often greatly ſwelled or enlarged into tumors. Theſe ligatures will ſerve to keep the blood in any limb round which they are tied, that it may not return to the heart and be loſt through a wound in another part.

LXVII. The experiments to prove this courſe of the blood, which have been made in living animals, are ſtill more accurate. From them, even from our own, it appears, that by tying any vein, in a living animal, near the cava, or belonging to the pulmonary veins, that part always ſwells which is moſt remote from the heart, all below the ligature appearing diſtended with the retained blood, while above and next the heart they are pale and flaccid. Laſtly, if the arteries are tied at the ſame time with the veins, theſe laſt remain flaccid and empty; but, upon removing the ligature from the arteries, the veins are immediately filled.

LXVIII. In like manner, the infuſion of poiſons or medicinal liquors ſhow, that, into whatever vein you inject chemical acid ſpirits, the blood is driven along with the force of the poiſon to the heart itſelf. But when, from this cauſe, the brain is affected with the narcotic virtue of opium, and the inteſtines and ſtomach with the virtue of purgatives and emetics, this is a demonſtration that the blood, with which theſe ſubſtances were mixed, had paſſed through the ramifications of the veins to the heart, and from thence thro' the whole body.

LXIX. Another proof we have in the *transfuſions* of blood; in which all the blood from the arteries of one animal is urged into the veins of another exhauſted of blood; whereby the heart, arteries, and empty veins of the latter become ſo turgid and well repleniſhed, that they work the whole machine of the animal with a remarkable degree of vivacity, or even cauſe it to labour under a plethora.

LXX. But that the blood paſſes from the leaſt arteries into the leaſt veins, we are clearly taught by *anatomical injection;* where, by one arterial trunk, we eaſily fill all the arteries and veins, almoſt throughout the whole body; provided the liquor be watery or very fluid, ſo as to paſs eaſily in the veſſels of the head, meſentery, heart, and lungs.

LXXI. Laſtly, *the microſcope* has put the matter beyond all doubt in the pellucid tails, feet, and meſenteries, of animals; where we ſee that the blood, brought to the extreme parts by the arteries, is poured either into ſmall veins, continuous with the reflexed artery, or elſe goes through branches of the arterial trunk into the parallel communicating vein, by which it goes on to the parts neareſt the heart. This is the way in which the blood paſſes as well into the leaſt veins which are capable of receiving only one globule, as into thoſe that are ſomewhat larger, being able to admit two or more globules to advance forward in a breaſt. But that there is no ſpongy or parenchymous interpoſition betwixt the arteries and veins, in the general courſe of the circulation, is proved both from microſcopes and injections. For if there were any ſuch parenchyma or ſpongy maſs betwixt the arteries and veins, the hardening injections would ſhow it, by appearing extravaſated in a like unſhapen maſs.

LXXII. The circulation of the blood is, therefore, now received by every one as a medical truth; namely, that all the blood of the human body is carried through the aorta, from the left cavity of the heart, to the extreme parts or converging ends of the arterial branches; from whence the whole maſs is again tranſmitted into the leaſt veins, which convey it to the larger, and from them into the cava and heart itſelf; in which courſe it perpetually goes and returns during life.

LXXIII. Yet there are ſome inſtances where, by paſſions of the mind, a ſudden revulſion by copious blood-letting, or convulſions, the blood has been forced to recede back from the ſmaller into the larger arteries; and, on the other ſide, where an obſtruction being formed above the valves, the blood has been known to ſlide back from the venous trunks into their ſmaller branches. But then theſe accidents are very momentaneous or ſudden, and the blood ſoon returns into its natural courſe. Theſe things happen moſt frequently in the abdomen and vena portarum.

abrupt)

LXXIV. The courſe of the humours *in the lymphatic veins* which have valves, appears both from the nature of thoſe veins, and from ligatures: for every lymphatic vein tied ſwells betwixt the ſmaller extremities of it and the thoracic duct; but grows flaccid betwixt the ſaid duct and the ligature. All the valves in theſe, like thoſe of the blood-veins, give a free paſſage for flatus and mercury to flow to the thoracic duct: but they make a reſiſtance, and often an obſtinate one, to any return the other way; although ſometimes they have been known to yield [39].

LXXV. *The vapours* that moiſten the whole cellular ſubſtance, the ſteams of the abdomen and other venters, are all thus drunk up by the leaſt pellucid veins, and ſo conveyed to the blood-veins, that their contained juices may paſs on to the heart: and from thence it is, that œdema enſues, when a vein is compreſſed by a ligature; becauſe by intercepting the courſe of the abſorbing veins by the ligature, the vapours ſtagnate unabſorbed. In the other ſmaller veſſels, we can make no experiments: but they appear conformable to what we have ſaid, both from reaſon and analogy; and are likewiſe ſupported by the experiments of water or other liquors, abſorbed out of the cavity of the inteſtines, thorax, and pulmonary veſicles.

LXXVI. All juices, therefore, in the human body, are drove out of the heart into the aorta; from whence they are all returned again to the heart by the leaſt veins;

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[39] I have ſometimes found that they admit a fluid in a contrary direction, when I was puſhing air through the lymphatic veſſels of a dropſical ovarium into the leſſer plexuſes, and mercury from the thoracic duct into ſeveral lacteal veſſels of the meſentery, and the lymphatics of the loins and pelvis; it goes backwards alſo in the hepatic plexuſes; but I confeſs I never ſucceeded in the joints,

veins; thoſe humours only excepted, which are exhaled or diſcharged withoutſide the cavities of the body. To complete this circle, it only remains for us to find out a courſe for the blood, from the right to the left cavities of the heart: but then this ſuppoſes us to be firſt acquainted with the hiſtory of the heart, and the pulmonary veſſels.

CHAP. V.

Of the HEART.

LXXVII. THE fabric of the *thorax*, compoſed of bones and cartilages in general, reſembles a truncated cone, as we ſhall afterwards remark. The lateral parts of this cone are two membranous bags, terminated above by an obtuſe end at the firſt rib, where they lie very near together, and are diſtinguiſhed by the interpoſed cellular ſubſtance only. The obliquity of the plane, dividing theſe two bags, is ſuch, that the right is much the broadeſt, and adheres in its deſcent all along to the whole middle of the ſternum; but, in its deſcent, is inclined to the left ſide, and comes from the margin of the ſternum itſelf; while the left bag deſcends, not from the ſternum, but from the cartilaginous ends of the ribs. The inner central ſides of theſe bags, oppoſed one againſt the other, make up what anatomiſts call the *mediaſtinum.* Theſe bags have no where any communication one with the other; ſo that the right may be opened, and the lungs therein may be deſtroyed, without injuring the left. But the ſimple denſe membrane, which forms theſe bags outwardly inveſted with the cellular ſubſtance, is called the *pleura;* being harder than the peritonæum, eſpecially where it adheres to the back; but is ſomewhat ſofter in its fore part, and is almoſt deſtitute of feeling[40]. The capacity of the mediaſtinum, or that interval which lies betwixt the right and left bag, broadeſt above, and likewiſe below, contains the thymus, and ſome conglobate glandules, fat, and veſſels, and, in ſome diſeaſes, pus.

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[40] It indeed wants that degree of ſenſibility which other parts ſhow that are furniſhed with more nerves; but whether the pleura,

LXXVIII. Below, the ſame bags, growing broader, depart one from the other, and leave a capacity thro' the whole middle part of their extent, by which the ſaid bags are divided one from the other. And this capacity is that of the pericardium. But the bags of the pleura on each ſide of the pericardium, deſcending both before and behind it, terminate finally on the diaphragm, about the fifth or ſixth rib; and on this their baſe is cut off obliquely, ſo that each cavity is before ſhorter in the fore part, as behind they deſcend longer and lower, in ſuch a manner as to be hollow in the upper part. Theſe bags contain the lungs. The back parts likewiſe of theſe bags are more tender; and though they lie near to each other, are yet ſeparated by the cellular ſubſtance which terminates in the pericardium, and includes the aorta, together with the œſophagus; and this we call the *poſterior mediaſtinum*. The triangular productions of the ſides of the mediaſtinum form the ligaments of both lobes of the lungs.

LXXIX. The *pericardium*, or third bag, which firſt the cellular ſubſtance, and then the conjoined pleura, looſely cover on all ſides as an outer coat, touches the ſternum indeed but by a very ſmall part; ſince the lungs, when diſtended, cover the heart almoſt wholly before, and interpoſe betwixt the ſternum and pericardium in their lower part; and the mediaſtinum, gradually diverging towards the left ſide, forms quite a narrow interval under the lower end of the thymus, cloſe to which the lungs meet on each ſide: but this ſituation you will derange, unleſs you are very careful in your manner of opening the thorax

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pleura, in proportion to its want of nerves, is perfectly deſtitute of the feeling power, we ſhall, when opportunity offers, make farther inquiry (CCCLXV).

thorax. The pericardium has a broad, but ſomewhat round, baſis, adhering to the tendinous part of the diaphragm, and by a ſmall part to the fleſhy ſubſtance of the ſeptum on the left ſide about the fifth or ſixth rib. In young ſubjects it adheres more laxly; but in adults very firmly, by the cellular ſubſtance ſpreading broader to the right and narrower towards the left. It is ſomewhat larger than the heart; which, therefore, may move freely therein. This membranous capſule or fence of the heart, was never known to be abſent [41].

LXXX. Upwards the pericardium grows gradually narrower, ending above the heart in an obtuſe conical appendix, extended over the coats of the large blood-veſſels almoſt to the upper edge of the ſternum. It adheres firſt to the inferior branch of the right ſuperior pulmonary vein; then to the vena cava; after that to the aorta, on its acceſſion to which it riſes higher up; then it adheres to the deſcending trunk of the ſame veſſel, and to the ductus arterioſus; from hence it is ſpread upon the left branch of the pulmonary artery; then on both branches of the left ſuperior pulmonary vein. On the back part it is again attached to the right pulmonary vein; then to the left ſinus, to both pulmonary veins on the left ſide, and to the auricle of the ſame ſide; from thence it proceeds a long way from the pulmonary vein even to the inferior cava, then to the ſeptum of the ſinuſes, then to the inferior cava. Beſides, it goes to the pulmonary artery, its right branch, and the aorta under the origin of the large branches, in ſuch a manner as to ſurround both arteries with a cylindrical production of its ſubſtance, whence it appears like a kind of partition between every two neighbouring veſſels. Thus alſo it contains the vena cava ſuperior as in a ring, the anterior and poſterior cavities of the pericardium being freely continued between that vein and the aorta. In like manner it ſurrounds the inferior cava. But this ſheath, by which the veſſels are ſurrounded, preſerves its nature only for a ſhort ſpace, and immediately returns to the heart with thoſe large veſſels to which it ſerved as an external coat. It alſo ſends a cellular fabric like a ſheath, along with the great arteries and veins, to the lungs[42].

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[41] Nor is it really wanting in ſome quadrupeds, as the hedgehog, to which it has been refuſed, but only more tightly tied to the heart.

LXXXI. The *arteries* of the pericardium are either from thoſe of the thymus, which accompany the upper and lower phrenic nerves, or from the larger phrenic arteries, from the branches of the mammaries and mediaſtinals, the bronchial, œſophagal, and poſterior mediaſtinal arteries, or from the coronaries which inoſculate with the bronchials and others. The *venous trunks* of the pericardium have a like origination, but appear with moſt evident anaſtomoſes from thoſe of the right into the others of the left ſide. The *nerves* of the pericardium are from the ſuperficial branches of the cardiacs.

LXXXII. That which makes the proper ſubſtance of the pericardium, is a ſtrong, white, compact membrane, more robuſt than the aorta itſelf, through which the nerves of the heart and ſome ſmall veſſels deſcend. Its outer ſurface being ſpread with the cellular ſubſtance, gives it there a ſomewhat rough appearance, while internally it appears highly poliſhed, and moiſtened on all ſides by a watery vapour. This vapour, which we have, times without number, obſerved in the living animal, compoſes ſome, though naturally a very ſmall quantity, of a water within the pericardium; which is either limpid, yellowiſh, or reddiſh, and ſubviſcid or gelatinous; by diſeaſe, it is ſometimes increaſed to an immenſe quantity; yet the exiſtence of ſuch a water here is injudiciouſly denied by ſome. The *water* of the pericardium is of a lymphatic nature; becauſe by heat it hardens into a jelly; and from hence ſmall fibres and a cellular ſubſtance are often found, in ſome diſeaſes, mixed with the natural viſcous humour which every where exſudes from the heart and its pericardium. This liquor is ſeparated without any intermediate glandules, or any viſible pores, from the ſmall exhaling arteries of the heart, auricles, and pericardium; as may be proved by a ſimilar tranſudation of water or fiſh-glue injected into the large arteries.

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[42] It is more rare, and belongs only to varieties, when appendices are found in the pericardium; ſuch as I have ſeen ſent to the under lobe of the lungs of the left ſide, an inch long, and even more.

LXXXIII. The *uſe* of the pericardium is to contain the heart along with this vapour; and to ſupport and ſtrengthen it as a fulcrum or prop, that, in contraction, the fibres of the heart may be drawn together without diſtorting the large blood-veſſels, and that by its vibration may not be ſenſible of altering the poſition of the body. For theſe reaſons we find it in all animals that have a true heart. A watery vapour here bedews the heart, which is hotter and quicker moved than other parts, ſo as to hinder attrition and coheſion betwixt it and the pericardium; but when this vapour is dried up, or deficient, the pericardium adheres either to ſome one part only of the heart, or to its whole ſurface, ſo that it ſometimes ſeems to be entirely wanting.

LXXXIV. Nature hath given a heart to moſt animals[43], even to many inſects and worms: to others ſhe hath denied it; and theſe are the moſt ſimple of all animals, even very large ones, though they are irritable throughout their whole body; as, for inſtance, he prickly hydra. Thoſe animals who have no hearts, have alſo no veſſels.

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[43] The heart, with reſpect to the cavities, and the veſſels which correſpond with theſe cavities, may, in the more perfect animals, be divided into two claſſes. For thoſe animals which have no real lungs to complete reſpiration and circulation, are furniſhed only with a bilocular heart, one ſinus which receives the blood, and one ventricle which ſends out an artery; as in fiſhes, and almoſt al amphibia. But a quadrilocular heart is always an attendant upon real lungs, receiving a great part of the blood, and it is obſerved to be formed of two ſinuſes, with as many correſponding veins, and of two ventricles ſending out two arteries; as in quadrupeds, birds, cetacea, if we credit Raius.

LXXXV. The veins which carry back the blood from the whole body to the heart, if we except thoſe of the lungs, are reducible to two[44]. The *cava* is improperly named in the ſingular by anatomiſts, ſince it is no where, or for a very ſhort ſpace, one ſingle trunk. The lower of the two large veins, which is the biggeſt of them in man, aſcends immediately above the diaphragm from the right ſide, towards which it is a little convex or gibbous, to its union with the upper cava; and, together with that in its back part, forms a middle partition betwixt the right and left ſinus: but the left ſide of the venous tube degenerates into the right auricle, whoſe fibres are a continuation from thoſe of the cava. What we have here ſaid of the lower cava is alſo true of the upper.

LXXXVI. Thus by the meeting of the upper and lower cava, a ſinus or cavity is formed with a convexity to the right, and inwardly filled with ſtrong, fleſhy fibres, detached betwixt the two ſimple membranes, and variouſly interwoven. But the ſame cavity, to the left and fore part, dilates forwards into an almoſt perpendicularly oblong or oval form, and terminates above with a blind-pointed end, which is free from adheſion with the heart, and lies incumbent on the great artery. This cavity alſo, like the former, has plenty of fleſhy fibres placed betwixt two very thin membranes, almoſt in a parallel poſition; and theſe form a kind of arch, extended from the right to the left edge of the whole cavity, and round the anterior half cylinder of this cavity; and theſe muſcular arches are connected together by ſome of the leaſt fibres. This anterior part of the cavity is called the *auricle;*

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[44] Theſe are very rarely found, when all the veins of the left ſide of the head, the neck, arm, and thorax, have run into one common trunk, which is directed to the ſinus of the venæ cavæ.

ricle; but that to the right and poſterior part is called the *ſinus*[45]: it is thin at the partition of the auricles, and likewiſe between the oval ring and where the vena cava enters the heart. In this appendix there ſeem to be three large muſcles, the anterior, poſterior, and inferior.

LXXXVII. In the partition which ſeparates the two auricles, the baſis lying in the middle between the two venæ cavæ is depreſſed to the left ſide, more on the upper and leſs on the under part; and, at its baſis, the partition is exceedingly thin. I ſhall call it the *oval foſſa.* It is bounded on both ſides by a fleſhy column, by the union of which an arch is formed at top, while the thinner parts at bottom are turned backwards to meet one another. This I call the *oval ring;* others, the *iſthmus.*

LXXXVIII. Where the lower cava opens into the right auricle[46], from the tumid column of the left ſide of the foramen ovale ariſes a moon-like membrane, naturally complete in its figure, and from its thinneſs in adults ſometimes net-like: and this being extended round the lower edge of the auricle, grows thinner all the way, as it is incurvated to the right; but does not quite ſurround half of the auricular circumference, the cavity of which it ſerves like a partition to divide from the vena cava. This is called *Euſtachius's valve.* The oval foramen we ſhall deſcribe hereafter.

LXXXIX. The blood of the two venæ cavæ is propelled by a muſcular force, in either vein, into this *atrium* or porch of the heart, compoſed of the ſinus and auricle. Theſe veins, as far as they lie within the breaſt, are endowed with ſtrong and irritable muſcular fibres, by whoſe contraction the blood is driven into the neighbouring auricle.

XC. In like manner, the auricle, being irritated, is contracted on all ſides. And, firſt, by a conſtriction of its muſcular fibres, the anterior ſemicylinder of the auricle is reduced to a plane; while the ſame fibres, by their contraction, bring back the middle arch towards the anterior extremity or beginning of the heart, and likewiſe towards its poſterior extremity or ſinus. Then the appendix to the auricle deſcends, and is contracted tranſverſely by itſelf, while the lower part aſcends; and thus the auricle becomes ſhorter. Again, the left edge turns evidently to the right, and the right edge a little to the left; and thus the auricle is rendered narrower. Thus the blood of both cavæ, being mixed together in the beginning of the heart now diſencumbered, is driven through the edges of the open valve, in ſuch a manner as to urge the valves of the right ventricle cloſe to the ſides of the heart. But the blood is now hindered from returning again into the lower cava, both by the contraction of the auricle, the reſiſtance of the ſucceeding blood from the abdomen, and of the *Euſtachian valve;* and upwards it is hindered from aſcending, both by the motion and weight of the conſequent blood. It is driven back, however, on both ſides, if there happens to be any obſtacle in the lungs.

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[45] The ſinus of the venæ cavæ is a very proper name, as the ancient names of right and anterior are very ambiguous.

[46] Or, according to Wolfe's opinion, it opens into each ſinus in the fœtus.

XCI. The *figure of the heart* itſelf, in ſome meaſure, reſembles half a cone, if the cone be ſplit into two longitudinally in the direction of is axis. It is almoſt triangular; only the end of it is obtuſe, and the lower ſide of it is flattened in proportion to the diaphragm on which it lies incumbent, and is thereby ſuſtained. But the convex ſurface of the cone is ſo inclined within the pericardium, under the great blood-veſſels, as ſuffices to place its thicker ſemicircular curvature, which modern anatomiſts call its *obtuſe margin*, directed to the upper and to the left ſide of the breaſt: in its lower and anterior part, the heart is alſo extenuated into a kind of edge, which is called its *acute margin;* but the point is turned a little forwards. This is the general ſituation of it in mankind; but in brutes, the heart being almoſt parallel to the larger axis of the thorax, its apex or tips only extend to touch the diaphragm.

XCII. The whole heart is hollow, having its *anterior*, formerly called its *right ventricle*, communicating into the right auricle and ſinus[47], which is broad and ſhaped like the fourth part of a cone; not ſo long as the poſterior left ventricle, but larger; and it terminates in the ſhorter tip of the bifurcated apex of the heart. The mouth of this ventricle, where it opens into the auricle, is elliptical; and terminated by a white glutinous margin, more callous than tendinous: over this, plates of muſcular fibres are ſpread, and ſome fat lies outwardly upon theſe.

XCIII. From this callous margin is extended, within the heart, a membranous ring, formed by a reduplication of the internal membrane of the auricle, extended ſo as to float within the ventricle to which it was before continuous. But this ſame ring, in that part which fluctuates in the ventricle, is ſo ſplit or divided into three unequal triangular portions, that you may in ſome meaſure give them the name of valves, and count three of them in number, although they are in fact only continued parts from one broader ring. Theſe were, by the ancients, named *triglochines*, or *valvulæ tricuſpidales*[48].

XCIV. That part of theſe valves which lies next to the ſides of the heart is ſtrengthened by tendinous fibres, which, meeting together in their courſe, are inſerted by very ſtrong cords, partly into the ſides of the heart, and partly into papillary or cylindrical muſcles, which ariſe upward from the left ſide of the right ventricle towards its right ſide. The largeſt of theſe muſcular columns is that which anſwers to the biggeſt of the valves, which is both the uppermoſt and that which anſwers to the adjacent mouth of the pulmonary artery. The leaſt of them is the loweſt, and is ſituated before the acute margin.

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[47] I call it the *ventriculus pulmonaris*, ſince it alone conveys the blood into the lungs, and is wanting in animals which draw in a great deal of blood.

[48] It is a better name, *valvulæ venoſæ ventriculi pulmonaris*, as it pointedly marks the courſe of the venous blood.

XCV. The uſefulneſs of this valve is evident enough; for the right auricle (XC.) being contracted, the blood contained in the right porch of the heart, at the looſe extremity of the auricle, being impelled from the circumference towards the axis, like a wedge, ſeparates the pendulous portions of the ring, called *tricuſpid valves*, and preſſes them to the ſides of the heart. Thus is filled the right ventricle of the heart, while the uppermoſt valve (XCIV.) ſhuts the pulmonary artery, leſt the blood, by the weak impulſe of the auricle, ſhould flow into that artery: the blood thus received, and confined within the right ventricle of the heart, is, by the ſtrong contraction thereof, more powerfully expelled into the artery.

XCVI. The ſenſible fleſh of the heart, being irritated by the quantity and weight of this warm blood, is thereby ſolicited to a contraction: for that the heart, being irritated, will contract itſelf in a perſon dying, or even lately dead, is proved by injections of water, and inflations of air, whereby the heart, then quieſcent, is recalled to its motion.

XCVII. The heart's motion is performed by *muſcular fibres;* the originations of which, in general, are from rings formed of the cellular ſubſtance, compacted into a callous ligament, agreeable to the deſcription given in XCII. and with which all the larger blood-veſſels at their opening into the heart are ſurrounded. From thence the fibres, which ariſe, deſcend gradually in an oblique winding courſe towards the left ſide, and forward to the apex, in many diſtinct plates, and ſometimes a little traverſing each other, the middle ones being the moſt tranſverſe, while the outermoſt and innermoſt deſcend in a ſtraighter line. In the flat ſide of the heart (XCI.) there are few fibres; and ſo thin, that when you have removed the fat, the cavity appears almoſt uncovered. That which is called the left ventricle, is, however, very firmly inveſted by the fibres; which, after ſurrounding the ſame ventricle, form a ſlight decuſſation in the ſeptum cordis with the fibres of the right ventricle, and are interwoven with them. Some of theſe fibres deſcend into the cavities of the ventricles, and form there the fleſhy columns mentioned at XCIV. Others at the tip of the heart, are wound in a vortical or whirling poſition, the two horns ending by a ſtrong faſciculus or bunch in each ventricle. A very thin and ſmooth membrane covers the external and internal ſurface of theſe fibres; but the external membrane, eſpecially where it is ſpread over the coronary veſſels, contains much fat beneath it. I have, for my own part, not been able to diſtinguiſh any thing more particular in the muſcular fabric of the heart, with any tolerable degree of evidence; becauſe it is the peculiar property of the fibres in the heart to join together in branchy appendices or heaps, in ſo ſtrict union, that they cannot be ſeparated without laceration.

XCVIII. But there are ſeveral eminent anatomiſts, whoſe ingenuity and communicative freedom I reſpect, who have repreſented and deſcribed thoſe fibres diſplayed and ſeparated: namely, the external fibres of the heart, common to both ventricles, deſcending to the tip, and then, taking another courſe, to inſert themſelves into the ſeptum; others again, at the tip, to perforate the left ventricle, and return, in a contrary courſe, to the baſis along the inner ſurface of the ſaid ventricle. But the middle fibres, betwixt the aforeſaid inner and outermoſt ones, being variouſly inclined towards the baſis, form the ſeptum. And others have given us figures and deſcriptions of ſtill different orders of fibres, of which the outermoſt run counter to the innermoſt, while the intermediate are tranſverſe. To which deſcriptions, as they are not much different from my own obſervations, I ſhall make no oppoſition, although I have never been able to ſee this diſpoſition of them ſufficiently manifeſt, and am acquainted with great anatomiſts who have not been more ſucceſsful than myſelf.

XCIX. Theſe fibres of the heart, like other muſcles, are furniſhed with *nerves* of their own, very numerous and of various origin. The firſt and uppermoſt are on the left ſide[49] from the ganglion of the intercoſtal with the uppermoſt cervical nerve. With theſe are joined others from the pharyngeal plexus of ſoft nerves; others, produced from the pharyngeal and gloſſo-pharyngeal ganglions, are mixed with them; others alſo are added from the trunk of the intercoſtal nerves; and others from the middle ganglion ſeated on the ſtraight muſcle about the paſſage of the thyroid artery, which has branches both from that uppermoſt nerve and from the trunk of the intercoſtal and phrenic nerves. Others come from the recurrent nerve of the eighth pair. The nerves of the heart, originating from theſe ſources, (wove together into a plexus, partly before the great artery, in which the following ones are mixed together; and partly forming ſeveral ſmall plexuſes between the aſpera arteria and the large arteries going out of the heart), form one or more plexuſes out of the nerves of the right and left ſide; which plexuſes are commonly joined together, though ſometimes they are diſtinct. From this ſame plexus, or plexuſes, other

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[49] Upon comparing my own obſervations with Anderſch's and Neubaver's deſcription of the cardiac nerves, I ſee that the riſe on each ſide, courſe, and manifold intermixture of the cardiac nerves, if you except the deeper deſcent of the eighth pair of the left ſide into the thorax, and the more remote origin of the recurrens ariſing from thence, are very ſimilar; ſo that I have nothing to add: But among the cardiac branches I found a greater one in ſeveral ſubjects; of which, as it is not ſufficiently underſtood, I ſhall add a deſcription. From the great cardiac plexus, which the uſual filaments form, five or ſix ſmall nerves, forming a net-work, at length run together into one trunk, a little leſs than the recurrent: while it deſcends into the ſoft cellular ſubſtance, cloſe to the aſpera arteria, it runs with the various furrows of the plexus pulmonaris out of the eighth pair; then it is divided between the aorta and pulmonary artery into two branches, and ends partly in theſe arteries and partly in the right ſide of the heart.

nervous twigs paſs betwixt the aorta and pulmonary artery to the right artery of the heart; others croſs the pulmonary artery, and go betwixt it and the left auricle to the coronary artery of the ſame ſide; others behind the pulmonary artery to the ſame coronary; and others, again, deſcend very deeply behind the pulmonary artery to the left ſinus and flat ſurface of the heart. To the cardiac plexus, above deſcribed, other large nerves accede from the fifth and lower cervicals, and ſometimes from the phrenic nerve, and from a ganglion of the loweſt cervical with the intercoſtal, to which join large roots from the loweſt cervical nerves. The laſt deſcribed nerves, which are larger, ſofter, and more tranſverſely diſpoſed, are partly mixed with the foregoing plexus, and partly go to the lungs. Laſtly, there are ſome ſmall branches, uncertain as to courſe and number, which join the cardiac plexus from the recurrent and eighth pair of nerves; and making various inoſculations with the intercoſtals, are confounded with thoſe of the eighth pair. As for thoſe nerves, which ſome eminent anatomiſts have ſeen aſcending from the great abdominal plexus to the heart, through the foramen of the vena cava, I have never been able to find ſuch; although it is eaſy enough to diſcover the diaphragmatics in that place, having ganglions peculiar to themſelves, of which thoſe anatomiſts make no mention.

C. That theſe nerves conduce powerfully to move the heart, is the opinion of eminent anatomiſts, from a conſideration of the common nature of muſcles; and from the increaſe which follows in the heart's motion, by irritating the eighth pair of nerves, either at the brain or the ſpinal medulla; and from the languor that enſues upon tying thoſe nerves, which proves fatal, either ſuddenly or within a few days, even though you happen to make the ligature on but a few of the nerves that come to the heart; for the intercoſtal, and eſpecially thoſe from the ganglion of the upper thoracic, cannot be tied.

CI. But that there are ſtill other cauſes, beſides that of the nerves, conducing to the motion of the heart, we are perſuaded from obſerving its motion undiſturbed by the irritation of all the nerves in the living animal; from its remaining after the greateſt wounds of the head, and even of the cerebellum and medulla ſpinalis; likewiſe from its motion when torn out of the breaſt; chiefly in thoſe animals whoſe lungs, being impermeable, make no reſiſtance to the heart's motion; for the motion of the heart is obſerved to be very vigorous in the fœtus before the brain is well formed, and likewiſe in animals wanting the head. And all our experiments agree in this, that the quieſcent heart in dead or dying animals, when irritated by heat, vapours, poiſons, and eſpecially impelled flatus, watery liquors, wax, or blood, or on receiving an electric ſpark, immediately contracts itſelf, putting all its fibres into a rapid motion, by a force ſometimes common throughout the whole heart, and ſometimes affecting only a particular part of it.

CII. Thus then we ſee, that there reſides in the heart a kind of impatience of ſtimulus; ſo that even in the viſcus, when almoſt dead, wrinkles, and motions of different kinds, appear to be propagated along its ſurface, from places as it were irradiating from points: again, the heart, when torn out and cold, on being pricked, inflated, or irritated, contracts itſelf; and its fibres, when diſſected, corrugate themſelves orbicularly, when there is neither nerve nor artery to bring it ſupplies of any kind. This irritability is greater, and remains longer in the heart, than in any other part of the body; ſeeing, by ſtimulating it, the motion of the heart may be renewed at a time, when that of no other muſcle can. The heart of the fœtus is moſt irritable, as well as larger, in proportion, than in adults; and moſt tenacious of its motion, even in the cold. That motion is *peculiar to the heart itſelf*; coming neither from the brain, nor the ſoul; ſeeing it remains in a dead animal even when the heart is torn out of the breaſt; neither can it, by any act of the will, be made either quicker or ſlower.

CIII. It is, therefore, evident, that the ſtimulus, occaſioned by the impulſe of the venous blood, cauſes the heart contract itſelf; and that this contraction is convulſive, made with great celerity, and a manifeſt corrugation of the fibres; whereby the whole heart becomes ſhorter, thicker, and harder; ſo that the left ventricle is drawn ſomewhat towards the ſeptum of the heart, and the right one much more. The baſe alſo advances towards the apex; but the apex more evidently towards the baſis. This I have often obſerved with the greateſt certainty in diſſecting brute animals; ſo that thoſe learned gentlemen muſt have ſome way or other been deceived, who have aſſerted, that the heart is elongated during its contraction. But the heart does not ſeem to turn pale in ſuch animals as have warm blood. Even the ſeptum of the heart is rendered ſhorter, and draws itſelf towards the baſis. By this action, the fleſhy parts of the heart ſwell inwardly, and compreſs the blood as they do the finger, when introduced into its cavities. But that the heart is accurately enough emptied in this action, appears from the event; the evident paleneſs of animals whoſe heart is white, as frogs and chickens; and from the internal ſurface being full of eminences, which exactly anſwer to oppoſite cavities, and to the thick reticular arms or columns interrupted by ſinuſes. And beſides, the apex of the heart, being contracted a little like a hook, ſtrikes againſt that part of the pericardium next the thorax. Forwards, there is alſo a pulſation from the left venal ſinus; which is at that time particularly filled. In exſpiration, the heart ſtrikes violently upwards and forwards. The truth of both theſe we know by experiment.

CIV. The blood, which is preſſed by the contracted heart (CIII), endeavours to eſcape in all directions; but being driven from the muſcular ſides, towards the axis of the ventricle, by the reaction of what is lodged betwixt the venal ring (XCIII.) and ſides of the heart, the looſer ends of the ſaid ring are driven forwards and extended inward at the ſame time. By this action upon the whole circumference of the ring, it not only becomes extended itſelf, but, at the ſame time, rejects a part of that blood into the right auricle, which had before deſcended into the cone of the open valve, whoſe ſides, now approaching, ſhut up the venous orifice more cloſely as the heart contracts more ſtrongly; by whoſe force the tricuſpid valves as they are called, would be preſſed reduplicated into the auricle, if the muſcular nipples (XCIV.) or columns did not keep down their edges, and hold them firmly by their contraction (which is the ſame with that of the heart) in ſuch a ſhape as will extend the annexed chords of the valve, without injuring them.

CV. But the niſus of the remaining blood, now reſiſted by the tricuſpids, ſeeks another courſe; and, whilſt the larger of thoſe valves that is ſeated to the right (XCIV.), advances from the ſide towards the axis of the heart, this leaves open the mouth of the pulmonary artery, which it before covered; whereupon the blood preſſing the valves in the mouth of the ſaid artery cloſe to its ſides thus ruſhes into it.

CVI. To deſcribe this more particularly; from the upper and poſterior part of the right ventricle, a way leads into the *artery*, taken in, as it were, between the fleſhy parts of the heart produced, and ſtrongly connected to it by a cellular callous ring, from whence the artery aſcends to the left backward, and diſplays itſelf behind the arch of the aorta. The ſtrength of this artery is not extraordinary, being much weaker than that of the aorta. But from the inner ſurface of the artery, where it is joined to the heart, *three ſemilunar valves* ariſe, by a reduplication of the arterial membranes extended upwards, and towards the axis, in an arch that is flat or obtuſe enough; and theſe valves always fluctuate with their edges at free liberty in a parabolical ſhape. The middle of the edges, in each of theſe valves, is generally divided, ſometimes in the fœtus itſelf, by a ſmall, denſe, callous body, of a conical ſhape, but made up of inclined planes; whereby each whole valve, in itſelf reſembling an half-moon, is thereby again ſubdivided into two leſs half-moons. Betwixt the two membranes of the valve, appear ſome muſcular or tendinous fibres, partly in a tranſverſe poſition; ſome of which hold faſt the valve to the next contiguous ſide of the heart, leaving ſometimes ſpaces betwixt them in a reticular manner. Other fibres aſcend from the baſis of the valve; and, by growing to the callous corpuſcle, draw back the ſaid valve, and open the ſinus.

CVII. Each of theſe valves, in conjunction with the ſides of the artery here diverging, intercept a ſpace, which is blind or impervious downward; but open upward in a parabolical ſhape, as we obſerved of the valves in the veins (XLIX.) When, therefore, the blood is impelled from the ſides towards the axis of the contracting heart, it endeavours to eſcape in the direction of the ſaid axis; and, by ruſhing forth like a wedge, betwixt the valves, preſſes their looſe ſail-like edges againſt the ſides of the pulmonary artery, ſo as to run freely out of the heart. The truth of this appears from the fabric, from injections, and from ligatures, which, by obſtructing the lungs, will not ſuffer the large cavities in the right ſide of the heart to be emptied.

CVIII. The blood now received into the pulmonary artery, goes on then to make its circulation through the lungs. That artery is firſt divided into two branches; of which the left, being leſs and ſhorter, enters directly into the ſubſtance of the lungs: but the right branch, being larger and longer, paſſes tranſverſely through the arch of the aorta; and, after going a little way behind the ſaid aorta, enters the correſponding lungs of the ſame ſide. From each of theſe branches, by a multiplied ſubdiviſion, ariſe the very leaſt arteries, ſome of which tranſmit the blood directly into the continued ſmall veins, and others exhale part of its aqueous juices into the pulmonary cells. That the blood goes thus directly from the arteries into the pulmonary veins, appears evidently from their ſtructure; alſo from a ligature, which, intercepting the blood's courſe, while the heart and lungs ſtill urge it, cauſes an aneuriſmatic dilatation of the artery; and from polypuſes, by which, the mouth of the pulmonary artery being obſtructed, the right cavities of the heart become monſtrouſly enlarged, and at length burſt, while the left remain empty. Laſtly, from injections; for water, fiſh-glue, and milk, are very eaſily forced, from the pulmonary artery into the vein, and from thence into the left cavity of the heart. But the direct anaſtomoſes or final openings of the arteries into the veins in the lungs, is proved even to the ſight by the microſcope, in frogs, &c.

CIX. Nor can the blood which has once entered the pulmonary artery return back again upon the heart; becauſe the valves therein (CVI.) are of ſuch dimenſions, that when diſtended, they perfectly ſhut up the opening at the heart; and are ſo ſtrong that they reſiſt a much greater force than the contraction of the pulmonary artery, without being conſtrained to yield. However, ſometimes, from a greater contractile force of the artery, they grow ſomewhat callous; or, from a laceration of their outer membrane, a bony matter is poured in betwixt the duplicature of the valves. For, when the blood, by the contraction of the artery, returns towards the heart, it meets and enters the open ſail-like concavities of the valves (CVII.) which are by that means expanded, and driven together towards an axis in the middle: whence the valves, once expanded, quite ſhut up the mouth of the artery, ſo as to leave not the leaſt ſlit open; for any opening that might be left, is precluded by the ſmall callous bodies remarked at CVI.

CX. The *pulmonary veins*, of which we ſhall ſay more hereafter, gather into larger branches, which, at laſt, terminate in four (ſeldom two, and ſtill more rarely into five) trunks; to which it has been cuſtomary to affix a name in the ſingular, by calling them the *pulmonary vein*[50]. Theſe enter the cavity of the pericardium, from whence they receive an external covering; and are then inſerted at angles into the ſquare left or *poſterior ſinus*, which is ſometimes likewiſe called the pulmonary ſinus. In this courſe the upper veins deſcend as the lower ones aſcend. But that theſe veins bring their blood towards the heart, in the ſame direction with the ſinus into which they open, is proved by a ligature, which cauſes a turgeſcence or ſwelling, from the blood retained, betwixt the ligature and the lungs.

CXI. This pulmonary ſinus, which is almoſt of a cubical figure, being firmly built of divers bundles of fibres running betwixt two membranes, has, forward and to the right, one ſingle ſide or partition, in common to itſelf and the right ſinus (LXXXVI.); but forward and to the left ſide, it goes into a conical appendix, which is divided into proceſſes or indentations, like a cock's comb; and, after two or three ſerpentine turnings, makes what is called *the left auricle*, incumbent on the left ventricle, and pointing forwards. Some of its fibres, as in the right auricle, by their bending, contract it into the form of an arch; others, coming from the origin of the appendix, and inſerted into its apex, depreſs it. This ſinus, with the left auricle, are ſomewhat leſs than the right ſinus and auricle.

CXII. In this left ſinus, the blood waits for the heart's relaxation; at which time the niſus of the blood impelled againſt the venous valves, and the contracting ſtronger force of the ſinus, grow leſs. Then the left ſinus ſtretches itſelf forward acroſs the heart, is contracted tranſverſely along with it, and the appendix becomes

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[50] The name of *ſinus venarum pulmonalium*, inſtead of *left* or *poſterior*, is for the ſame reaſon more proper, as this ſinus receives the pulmonary veins as the right does the cavæ.

comes evidently ſhorter and narrower. Thus the blood is driven into the left ventricle, in like manner as the right auricle impelled its blood into the right ventricle, (XCV.) For here, as before, a like membranous oval ring forms productions called *mitral valves*[51], of which there are uſually two only counted. Theſe valves are longer and ſtronger than thoſe of the right ventricle. They have each its own and ſeparate muſcular ſtructure; but it is much firmer than that of the tricuſpids. And here, more often than in the valves on the right ſide, we find cartilaginous tumours in the tendinous ſtrings, produced by the friction occaſioned by the great motion of the heart.

CXIII. From what has been ſaid, then, it appears, that the ſame blood is now arrived into the left ventricle of the heart, which was a little before ſent from the venæ cavæ into the right auricle (LXXXIX.), which drove it into the correſponding or right ventricle (XCV.); by which, again, it was urged into the pulmonary artery (CV.); and, from thence paſſing into the pulmonary veins, was conveyed into the left ſinus (CX.); and, out of this, we here find it driven into the left ventricle (CXII). This courſe of the blood, from one ſide of the heart to the other through the lungs, is called the pulmonary or leſſer circulation, and was known to many of the ancients. It is proved by the increaſed bulk of the pulmonary veins on the left ſide; and likewiſe of the right cavities of the heart, from an obſtruction of the entrance into the left ventricle.

CXIV. The *left*, or poſterior, and upper *ventricle*[52] of the heart, which is always firſt formed, and in a great number of animals the only one, makes up that part of its half cone-like body, which we before called obtuſe, (XCI.) It is ſome what narrower than the right ventricle, a little longer, rounder, and generally of a leſs capacity within. For the contents of this ventricle, are about two ounces, while thoſe of the right approach to three. Its fabric internally is reticular, but more nicely wrought than in the right ventricle; and within the mouth of the artery it is ſmooth: but its force is conſiderably greater, as the muſcular fleſh that ſurrounds it is much thicker and almoſt three times ſtronger. The ſeptum of the heart belongs moſtly to the left, but ſome part of it alſo to the right ventricle: the whole of it is reticulated in like manner; but ſolid, and incapable of ſuffering any injected liquid to paſs from one ventricle to another[53].

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[51] They ſomewhat reſemble a mitre: however, I prefer the name of *valvulæ venoſæ ventriculi aortici;* which appellation cannot be confounded with any other.

[52] This I would call, on account of the riſe of the aorta from it, *ventriculum aorticum.*

CXV. Again, this left ventricle, being inſtigated to motion by the impelled blood, does, from the ſame irritable nature before mentioned (CIII.), contract, and drive its contained blood with a violent motion in the direction of its axis, and determine it towards the baſis, at the time when the tip or cone of the heart is drawn nearer to its baſis. And ſince the apparatus of the *mitral valves* is here the ſame as in the tricuſpids, the venous blood now expanding the ring from whence they ariſe, removes that valve which lay againſt the mouth of the aorta, ſo as to open a way for itſelf to the artery; in dilating the mouth of which, the ſaid blood preſſes the ſemilunar valves, there placed, againſt the ſides of the aorta, into which it ruſhes with a violent impetus. This is proved by ocular demonſtration in living animals, where the left ventricle ſwells upon ſhutting the paſſage into the aorta.

CXVI. The *ſemilunar valves of the aorta* differ little from thoſe in the pulmonary artery: only as the opening is here greater, ſo the valves are proportionably larger and ſtronger, and are not ſo often found to want thoſe callous round bodies in the middle. The fibres too of the valves, both tranſverſe and aſcending, are here ſomewhat more conſpicuous.

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[53] Among the more rare varieties of parts, unleſs we chooſe to term it a diſeaſe, I would rank the caſe of a girl of ſeven years, who had a double exit from the pulmonary ventricle. For a little below the mouth of the pulmonary artery, another opening, ſomewhat leſs than the former, led into the true arterial duct of Botal, ſent into the aorta. The duct itſelf was perfectly open, as is uſual after birth: The aorta, therefore, in this ſubject, for ſeven years, received blood from each ventricle; the ſeptum, however, being all the while entirely ſound.

CXVII. After the contraction of the heart, follows its relaxation or diaſtole, in which it becomes empty, lax and ſoft, recovers its former length, the ventricles recede from the ſeptum, and the baſis from the apex. But, while it is in this ſtate, the blood in the auricles, having been as it were in a ſtate of expectation, ruſhes through the openings of the valves of the veins, dilates the oppoſite ſides of the heart, and makes it at once longer and larger. After the auricles have freed themſelves of the blood they contained, they are in like manner relaxed, and their oppoſite ſides remove from each other. Then the blood, collected in the venæ cavæ and pulmonary veins, fills the auricles by the contraction of the veins; renders them long, broad, and thick, like the ventricles; and even diſtends and fills the tooth-like proceſſes of the creſted margin. That the fibres of the heart are not dilated, is proved from the junction of thoſe fibres; which, being tied together by their middle branches, cannot be ſeparated: alſo, by the diſſections of live animals, in which the whole heart is ſhown to be contracted.

CXVIII. But we muſt now conſider, that theſe motions of the right and left auricle, with the right and left ventricle, are not performed in that ſucceſſion in which, for the ſake of method, we have here deſcribed them; for both the auricles are contracted, while the ventricles are relaxed: ſo that the contraction of the auricles precedes the contraction of the ventricles; as we are aſſured from manifeſt experiments on dying animals, and on thoſe whoſe living blood is cold. But both auricles are filled together in the firſt inſtant, as both of them are emptied together in the ſecond inſtant; and both the ventricles are contracted together in the third inſtant, which is the ſame with the firſt; and both ventricles being evacuated, are relaxed in the fourth inſtant, which is the ſame with the ſecond. Thoſe who have inadvertently taught otherwiſe, have not taken the advantage of making a ſufficient number of experiments on living animals[54]. That the auricle, near death, makes frequent palpitations before the ventricle of the heart performs one contraction, is true enough. The auricle with its ſinus forms one cavity, and both are filled and both emptied in the ſame inſtant.

CXIX. But it may be aſked, Why the heart never ceaſes from *its perpetual motion*, through ſuch a number of years as there is in one's life, through ſo many days as there are in a year, and through ſo many hours as there are in a day; when, in each hour, the heart of a healthy perſon contracts not much leſs than 5000 times; ſo often are there ſucceſſive repletions followed with new contractions, perpetually in the ſame conſtant order; nor is there any muſcle, beſides the heart and diaphragm, but what becomes tired and painful, by acting inceſſantly, even for a few hours? Different anſwers have been given to this queſtion by different profeſſors, founded either upon a compreſſure of the cardiac nerves betwixt the large arteries, or upon an alternate repletion of the coronary arteries and cavities of the heart, &c.

CXX. But to me the ſimplicity of nature ſeems very great in this matter. When the auricle is relaxed, it is directly filled by the muſcular force of the continuous great vein; and ſo the heart alſo contracts itſelf, when it is irritated by the blood driven into it from the auricle. Therefore, the heart, having once received the blood, is contracted by that ſtimulus or, or irritable force, whereby muſcular fibres are excited into contraction; whereupon it empties itſelf of the blood; and being freed from the ſtimulus thereof, immediately reſts or relaxes itſelf. But the heart being now relaxed, the auricle is in like manner irritated by its contained blood, and by contracting fills it again; while the inceſſant actions of the heart and arteries continually urge new blood into the right ſinus and auricle. That this is the true ſtate of the heart's motions, is proved from actual experiment or obſervation; whereby we plainly diſcern the ſucceſſive repletions and contractions made in the great vein, auricle, ventricle, and artery, eaſily ſeen in a weak or expiring animal; but more eſpecially, and more evidently, in thoſe animals which have but one ventricle in the heart; as the tortoiſe, frog, ſnake, fiſhes; and in the chick hatching in the egg, which, inſtead of a heart, has only one crooked canal. Beſides, it is confirmed from the inertia of the heart, produced by tying the veins; and from the return of its motion, when the ligatures are unlooſed; provided theſe phenomena are ſufficiently valid: but this is more unequivocally corroborated by injection, and by the perpetual contraction of a frog's heart, from the inflation of a bubble of air, which many hours it alternately ejects and receives into the auricle. The left ventricle firſt ceaſes its motion; then the auricle of that ſide; then the right ventricle; after that, the right auricle; and, laſt of all, the pulmonary veins and venæ cavæ. Whatever motion is in the venæ cavæ, ought to be attributed to the auricle repelling the blood into both theſe veins, and which the heart, when dead, is not capable of receiving.

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[54] Obſervations upon living animals, and the reaſon of the thing itſelf, amidſt the three opinions of Lanciſius, Nichols, and Harvey, the laſt of which is very probable, ſeem to ſhow, that at one and the ſame inſtant the two ſyſtems of ventricle and veins are contracted, but that the ſinuſes and arteries are at reſt, or, if you chooſe, are dilated: but when the latter are contracted, the veins and ventricles are at reſt.

CXXI. Nor do I believe there is any thing more required to the heart's motion than a continual ſtimulus applied to a very irritable part. For, juſt upon the approach of death, the very coldneſs of the limbs, which the warmth of life has left, contracts the veins, and drives the blood to the heart; when the lungs, being impermeable for want of reſpiration, tranſmit no blood to the cavities of the left ſide. And, on the other hand, the heart, after it is thoroughly emptied, remains at reſt. It may thus happen, that, inſtead of the vena cava and right auricle, the laſt appearance of life may be transferred to the left auricle and ventricle; if we ſuppoſe the right cavities to be emptied, the left may be irritated by the blood contained in them. But if you derive the reſting of the heart from the compreſſion of its nerves, the motion of the auricles will be an objection, becauſe their nerves are not compreſſed. An example alſo we have in fiſh, and little chicken in the egg, where there can be no room for a compreſſure of the nerves. If, again, you deduce the heart's reſt from a compreſſure the coronary arteries, this is contrary to experience; ſince they are not covered by the valves of the aorta, and from a wound of the ſaid arteries, during the ſyſtole of the heart, the blood ſtarts out to a great height.

CXXII. Nor with the ſtrength of the heart do I join the oſcillations of the very ſmall veſſels, which is refuted by experiments: nor the force of external heat; ſeeing animals are found to live and thrive in the coldeſt regions of the north: and though the contractile force of the artery, and the weight of the parts and of the atmoſphere aſſiſt the motion of the blood during the diaſtole of the heart, the ſame powers reſiſt it during the ſyſtole; ſo that, indeed, by theſe means, the blood is moved no farther through the contractile arteries, than through the rigid arteries of ſmaller animals.

CXXIII. But with what celerity, and with *what force, the heart* drives forward the blood, is controverted, and variouſly computed. The more modern writers have raiſed their calculations upon a ſuppoſition, that, for the celerity to be determined, we are to admit two ounces of blood to iſſue out of the heart with ſuch a celerity, that the part of the pulſe, called its *ſyſtole,* makes one third of the whole pulſation, and is finiſhed within a $\frac{1}{225}$ part of a minute; but the area of the mouth of the aorta, they have eſtimated 0.4187 parts of an inch: ſo, by dividing the ſpace filled by two ounces of blood, (3.318 inches) by the area or ſection of the aorta at its mouth, [and length of its cylinder filled by two ounce, viz.$=7\frac{20309}{33180}$], the number thence produced divided by $\frac{1}{225}$, the time in which the heart contracts, they find 149 feet and two tenths of an inch for the ſpace through which the blood runs in a minute, if it goes on in a cylinder with the ſame velocity it firſt had from the heart. But the incumbent weight of blood moved by the heart, they have computed by the jirk wherein the blood ſtarts forth from the larger arteries in a living animal, being ſeven feet five tenths; and from the ſurface of the ventricle, whoſe area makes 15 inches. Thus 1350 cubical inches of blood, or 51 pounds five ounces, circulate, which preſs againſt the ventricle of the contracting heart. The heart, therefore, thus drives forward a weight of 51 pounds with a velocity by which it may run through 149 feet in a minute; which force it exerts four thouſand eight hundred times in an hour.

CXXIV. Although there are many particulars here unthought of which may render the eſtimate incomplete, and ſuch perhaps as we may never aſcertain; and although the mouth of the diſtended aorta may be wider in a living animal, though the area of the ventricle is of uncertain dimenſions, and the jirk of blood computed from an inſufficient height; yet if we conſider the violence with which the blood ſtarts from ſome of the leaſt ſanguine arteries in the living animal, although we cannot eaſily determine how much of the heart's ſyſtole is thus ſpent, variations in which will greatly alter the computation; yet, in the mean time, it will plainly appear, that the machine we call the heart is a very powerful one. The truth of this is evident from experiments; in which it appears to be very difficult to fill all the red blood-veſſels by anatomical injections, and quite impoſſible to fill all the ſmaller ones: yet the heart, we ſee, not only gradually diſtends all the larger, the ſmaller, and even the leaſt veſſels, with blood, but alſo drives it forward through them with a conſiderable celerity. Even in the leaſt arteries, the blood is urged forward by the heart with ſuch a force as to make the alternate motions of that muſcle perceptible. Likewiſe, in the veins and ſmaller veſſels of cold animals, even while contained in the inſect's egg, there is no other force beſides that of the heart, by which the blood is driven through their ſmall veſſels. And, from ſome of the leaſt arteries, I have ſeen the blood ſtart forth ſeveral feet, the jirk deſcribing a parabola, whoſe height was four feet, and amplitude of projection ſeven feet; and ſome aſſert, they have ſeen the blood aſcend from the aorta to the height of twelve feet.

CXXV. Moreover, that we may make a juſt eſtimate of the heart's force in living animals, we muſt conſider what great reſiſtances that complex muſcle overcomes: we muſt compute the enormous weight there is of the whole blood; a maſs, perhaps, of fifty pounds and upwards: for all that quantity of fluids, once ſtagnant in a perſon lately drowned or fainted away, are eaſily put into their former motion by the heart only[55]. We muſt again conſider the great decreaſe of the blood's velocity, ariſing from the geater light or capacity of the dividing branches, (from whence the ratio of its celerity, even in the inteſtines, may be computed to only a 24th or a 30th part of its original impulſe), abates two-thirds from the heart's force. And yet we ſee there are humours ſwiftly moved through the moſt minute veſſels; as, for example, the Sanctorian perſpiration, which, in a ſubterraneous cavern, I have obſerved to aſcend ſwiftly in form of ſmoke

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[55] The reſults from the lateſt experiments of Marher, Spallanzani, Fontana, Prochaſka, which appear in a contrary light to ſome, do not, when properly conſidered, greatly differ from Haller's opinion of the cauſe of the heart's motion, the change of figure during motion, the force and quickneſs, and duration of the action.

ſmoke or vapour; and the ſame celerity of the blood in the leaſt veſſels of little fiſhes, &c. is apparent to the eye by a microſcope. Now, ſince the frictions, in every machine, always conſume the greateſt part of the moving forces; much more do they in the human body, whoſe blood and juices are ſo much more viſcid or clammy than water, and driven through veſſels ſo ſmall, that they permit a globule only at a time to paſs through, and even hardly allow that without changing their figure: but from ſo ſtrong and extended a friction there muſt neceſſarily follow a very great hindrance to the motion; whence we may eaſily underſtand, that the force muſt be very great, which drives ſo ſwiftly ſuch a prodigious maſs of fluids in ſpite of ſo many reſiſtances and decrements of the moving forces. But, more than that, aneuriſms and arteries are burſt, and very great weights, as well as the body itſelf, raiſed by the force of the heart's ſyſtole.

CXXVI. The blood, being driven into the aorta, immediately finds the two openings of the coronary arteries, which lie next the arterial valves, but above them, or within the aorta; and in conſequence of this, it ruſhes firſt of all into the ſaid coronary arteries, by which the heart ſupplies itſelf with blood. Theſe arteries are for the moſt part two; the right goes off between the aorta and pulmonary artery, and the upper and left one between the left auricle and the aorta. All the external arteries are ſurrounded with much fat; but their cavity is more intercepted with valves than that of other arteries. Theſe arteries communicate, by inoſculations of the ſmall branches, every where about the ſeptum and tip of the heart; but they no where make a complete ring round the heart. They terminate in a two-fold manner.

CXXVII. The firſt termination of them is into the coronary veins, whoſe branches running in company with thoſe of the arteries, have their trunks of neceſſity diſpoſed in a different courſe. The *great coronary vein* is, therefore, a companion of the left coronary artery; and is inſerted with a large opening, ſecured with valves, or a number of little membranes, on the left ſide of the Euſtachian valve of the right auricle: the root of this ſurrounds the left auricle externally, and then accompanies the ſuperficial branches of the left artery.

CXXVIII. The other coronary vein (which you may make a part of the former, ſince they have both one common inſertion) deſcends along upon the ſeptum of the heart to its flat ſide; and may be properly called the *median coronary*. The *third* bends tranſverſly round the ſurface of the right auricle; and then terminates within, or at leaſt very near, the large opening of the coronary vein (CXXVII.) anteriorly. This vein ſupplies that part of the right ventricle which lies in the flat ſide of the heart; and often receives thoſe nameleſs veins we ſhall hereafter deſcribe.

CXXIX. There are ſtill ſome other *anterior veins* of the heart; but one more particularly large goes along the adjacent edge of the right ventricle, and, running for ſome length obliquely betwixt the membranes, is inſerted into the moſt anterior part of the right auricle, and ſometimes into the trunk of the upper vena cava. This anterior vein ſends off another concealed one through the root of the right ſinus; and, being again inſerted into the great coronary vein, it makes a complete circle round the heart, like the arterial circle which ſome have deſcribed, but has not yet been ſeen by me.

CXXX. But there are a great many more veins, uncertain in their number, which belong to the baſis and internal parts of the heart, to which the anatomiſt has ſeldom any acceſs, becauſe they lie concealed betwixt the origins of the large veſſels: and theſe open by numberleſs ſmall mouths into the right ſinus and auricle; and ſome, but a few only, into the left ſinus. Thus I have ſeen a particular vein, which, from a latent ſinus in the fleſh of the right auricle, has aſcended towards the aorta and pulmonary artery, and inſerted itſelf on one ſide into the greater coronary vein. Another I have obſerved, concealed betwixt the mouth of the coronary vein and the aorta, inſerted into the right ſinus; and another through the remains of the oval foramen, and ſeptum of the two ſinuſes, inſerting itſelf into the right ſinus; and others again belonging to the venous valves; beſides which, there are ſtill others too numerous to deſcribe. I have obſerved alſo a vein ariſing from the left ſinus and inſerted into the vena cava.

CXXXI. There are ſtill more, and much ſmaller, veins in the heart, whoſe little trunks, being very ſhort, cannot eaſily be traced by diſſection; and theſe open themſelves by an infinite number of oblique ſmall mouths, through all the numerous ſinuoſities obſervable on the ſurface of the right and left ventricle. Theſe are demonſtrated by injections of water, wind, or mercury, puſhed into the coronary arteries, after you have firſt tied their correſponding or accompanying coronary veins; or even into the great coronary veins, after you have firſt intercepted the openings of their largeſt trunks. For, in either of theſe caſes, there are drops of the tinctured water, bubbles of air, ſpherules of mercury, ruſhing out through the whole extended ſurfaces of both the ventricles of the heart; and this, without any violence that can be ſuppoſed ſufficient to break the veſſels. But the paſſage from the arteries into the cavities of the left ſide is more difficult.

CXXXII. There are ſome who will have the coronary arteries filled with blood, not by the contracting of the heart, but of the aorta in its ſyſtole; which they think muſt be a conſequence of the retrograde angle of the blood's courſe here, and the paleneſs of the contracted heart, with a ſuppoſition that the valves of the aorta cover or cloſe the mouths of the coronary arteries. But the two laſt of theſe are diſproved by experience; and the firſt, or retrograde courſe, can only impede or leſſen, and not intercept, the flux into the heart: for the injections of wind or mercury into all the ſeminal and biliary veſſels, demonſtrate that the large retrograde angles, which the veſſels often make there, do not hinder the fluids from taking, though they retard, their natural courſe. But a proof, ſtill more evident, is, that the coronary artery has a pulſe at the ſame time with all the other arteries in the body, and the blood ſtarting from it makes a higher ſaltus at the time when the heart is contracting (CXXI.)

CXXXIII. Concerning the reflux or return of blood from the muſcular ſubſtance of the heart, there is ſtill leſs room to doubt: for all the coronary veſſels diſcharge their blood into the auricles and ventricles, either right or left, (but leſs into the latter), both by the larger (CXXVII, CXXVIII, CXXIX.), the ſmaller (CXXX) as well as by the leaſt orifices (CXXI.), which ſo eaſily tranſmit injections, after you have firſt tied the larger coronary veins. The circulation thro' theſe veſſels ſeems to be completed in the ſhorteſt ſpace of time that can be neceſſary in any part, from the great velocity the blood receives from the heart itſelf, urging the ſame through its own ſubſtance. But that the whole contents of the veſſels are cleared in each contraction, does not ſeem to me probable; for the blood-veſſels of the heart do not look pale enough in that action to produce ſuch an effect as an entire evacuation. There is a very free or open paſſage from the arteries of the heart into the cellular ſubſtance, or fat which ſurrounds it. If you aſk, What are the uſes of thoſe leaſt or ſhorteſt veins which open obliquely through the ſurface of both the ventricles (CXXXI.)? they ſerve to return the blood of thoſe deeply ſeated ſmall arteries, which have no correſponding veins.

CXXXIV. The humours of the heart, which are thinner than blood, return by the valvular *lymphatic veins*, which accompany the coronary blood-veſſels, and aſcend towards the thoracic duct and ſubclavian vein; but they are to be very rarely ſeen, although I have obſerved them in brute animals.

CHAP. VI.

Of the Nature of the Blood *and* Juices *of the Human Body.*

CXXXV. THE liquor which is contained in the beating arteries and their correſponding veins, is called by one general name, the *blood:* which, to a looſe examination, appears homogeneous, or of ſimilar parts, red and coagulating throughout[56]; and is obſerved to be redder in proportion to the ſtrength of the animal: in a weak and famiſhed one, the blood inclines to a yellow: it hath a whiteneſs mixed with it, which comes almoſt totally from the chyle. But from various experiments it is certain, that this animal liquor contains very different ingredients.

CXXXVI. That fire is contained in the blood may be proved from its heat, which, in human blood, and that of ſome other animals, is from 92 to 100 degrees of Fahrenheit's thermometer, which is more than the mean degree of atmoſpherical heat, but leſs than the greateſt[57]. Again, a kind of volatile vapour or exhalation

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[56] As the blood has various degrees of redneſs in proportion to the diverſity of animals, from their age, food, temperament, and different exerciſe of body; ſo there are ſeveral morbid changes, which convert the blood from an intenſe red to the greateſt paleneſs; whence it becomes liker the vital liquid of more imperfect animals; as we remark in the jaundice, phthiſis, and dropſy, &c.

[57] The heat, which all perfect animals peculiarly poſſeſs in by far a greater degree than vegetables, from the more ſimple claſs of animals, through the various orders of fiſhes, amphibia, man, quadrupeds, and birds, at length gradually increaſes, till for the moſt part, in a natural ſtate, even at its greateſt heat, it does not exceed the 110th degree of Fahrenheit. Daily experience ſhows, that it differs in man, according to age, temperament, ſtate of mind, motion, or reſt of body, climate, weather, kind of life, meat and drink, health, and the various ſpecies and violence of diſeaſe. It is alſo certain that the degree of heat in the body increaſes

lation continually flies off from the warm blood, with a ſort of fetid odour intermediate betwixt that of the ſweat and urine. This vapour, after collection and condenſation in convenient veſſels, partakes of an aqueous nature, with ſomewhat of an alkaline quality.

CXXXVII. After this vapour has diſſipated, the blood of a healthy perſon ſpontaneouſly congeals into a ſciſſile trembling maſs; and with a leſs degree of heat than that of boiling water, (viz. 150 deg.) This toughneſs is greater in feveriſh perſons than in ſuch as are in health. It ſometimes coagulates in the veins of a living perſon, and is found clotted in wounds of the arteries. But even within the veſſels of a living perſon, and in one dying of a fever, the blood has been ſeen, by the violence of that diſtemper, changed into a concreted tremulous jelly throughout all the veins. The principal part of this coagulated maſs is the *craſſamentum* or *cruor*, which has the red colour peculiar to itſelf, and gives it to the other parts of the blood. This, if it be not kept fluid by the attrition of a vital circulation, or ſome ſimilar concuſſion, runs confuſedly into a compact, but ſoft maſs, like liver, merely by reſt and a moderate degree of cold; as it alſo does by the addition

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increaſes a little from an augmentation of heat in the atmoſphere; but it does not riſe to the greateſt pitch of ſummer-heat, although we can live in a much greater heat; as is proved by perſons employed in ſugar houſes, melting furnaces, by mowers, and the uſe of baths and ſtoves in Finland and Ruſſia; and alſo by the late experiments of Fordyce, Blagden, Hunter, and Dobſon. It is ſometimes ſo diminiſhed in an intenſe cold, that in a perſon froſt-bitten, but not dead, a thermometer applied to the mouth, armpits, groins, and even the vagina, would not riſe above 76° of Fahrenheit. But is the matter of heat in the blood alone? It is ſufficiently probable from phenomena; ſince the heat of the body is diminiſhed by hemorrhagy, or when the blood is intercepted by ligature and compreſſion from reaching the joints; it being reſtored when the blood returns. I muſt obſerve, however, that my experiments on living animals, particularly upon ſwine, did not diſcover ſo great a difference as might be expected, between the heat of the heart, the arteries, veins, brain, ſtomach, inteſtines, tunica vaginalis, and even the interſtices of the cellular texture in the muſcles.

tion of alcohol, by mineral acids, or by a heat of 150 degrees, of which 98 is the blood's heat in robuſt people. It is, either as a fluid or a ſolid, ſpecifically heavier than water by near an eleventh part; and, when freed from its water, it is wholly inflammable. In a maſs of healthy blood, one half or upwards is red cruor: and, in ſtrong laborious people, the ſerum makes only a third part; and is ſtill more diminiſhed in fevers, often to a fourth or fifth part of the maſs.

CXXXVIII. Another white, ſomewhat yellowiſh part of the blood, ſeparates from this coagulum, tranſuding, as it were, through its pores, and at laſt becomes a quantity, in which the coagulum ſinks: this again ſeems, though not really ſo, a homogeneous liquor. This part of the blood is, in general, one thirty-eighth part heavier than water, and almoſt a twelfth part lighter than the red globular maſs of craſſamentum: this too, by a heat of 150 deg. or by mixture of mineral acids or alcohol, and by a concuſſive motion, is coagulable into a much harder maſs than the red cruor (CXXXVII.); and forms an indiſſoluble glue, a fleſh-like membrane, which at length ſhrinks up to a horn-like ſubſtance, or friable gum. From thence are formed the pleuritic cruſts or ſkins, polypuſes, and artificial membranes. Beſides this coagulable albumen, ſimple water, of which there is the greateſt portion, is latent in this ſerum; and likewiſe a quantity of mucus, leſs capable of being drawn into threads than the red cruor; nor at the ſame time coagulable, like the albumen, by heat and acids[58].

CXXXIX. But by putrefaction only, or the diſſolving power of the air hot to 96 deg. equal to the blood's natural heat, the whole maſs, but eſpecially the ſerum, diſſolves or melts into a fetid liquor; firſt the ſerum, and then the cruor more ſlowly; till at length the

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[58] Haller has elſewhere properly remarked, that the received opinion of the elements of the blood is not hurt by Hewſon's diſcovery of a ſecond kind of lymph, which Krauſius has alſo allowed.

the whole maſs, both of ſerum and cruor, is turned into a volatile and fetid exhalation, leaving very few feces behind. The blood being a little diſſolved by putrefaction, and even before that, becomes fetid; with the fetor it aſſumes an alkaline nature; and effervesces with acids. This property it afterwards loſes, the alkaline ſalt being deſtroyed by putrefaction. The putrid blood cannot by any art be inſpiſſated, as it is alſo very difficult to be reſolved after it has been coagulated by ſpirit of wine. By too ſevere exerciſe, heat, and malignant diſorders, the coheſion of the blood is diſſolved, and it aſſumes an alkaline nature almoſt as if from putrefaction.

CXL. Beſides theſe parts of which the blood appears to conſiſt, without ſubjecting it to any violence, it contains in its ſubſtance a quantity of *ſea ſalt*, which is diſcernible to the taſte, and ſometimes viſible by the microſcope. That there is *earth* in the blood is demonſtrated from nutrition; and from a chemical analyſis, whereby the earth appears to lodge in the moſt fluid, and eſpecially in the oily parts of the blood. By ſome very late experiments, it appears, that a conſiderable quantity of ferruginous earth, eaſily reducible into metal by the addition of phlogiſton, is contained in the blood when calcined. Laſtly, another part in the blood is *air* in an unelaſtic ſtate[59], and that in a very conſiderable quantity; the exiſtence of which air in the blood and ſerum is proved by their putrefaction and diſtillation, or by removing the ambient air from them by the pump. But we are not to think, from hence, that the blood-globules are bubbles full of air, for they are ſpecifically heavier than the ſerum.

CXLI. By the admixture of neutral ſalts the colour of the blood becomes deeper and brighter, without being either diſſolved or thickened. It is ſcarcely altered by a weak acid. By fermented liquors it is coagulated. Fixed alkaline ſalts have almoſt the ſame effects as the neutrals. The volatile alkalis rather turn it brown, and coagulate it. Alcohol and diſtilled oils, and likewiſe vinegar, coagulate it. It does not efferveſce with any ſalt.

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[59] With the ſame propriety we mention the electric fluid; which, as it is communicated to us by reſpiration, we ſhall briefly conſider in the 8th chapter, along with that inelaſtic gas which has become ſo famous in our time.

CXLII. Chemiſtry has, in various ways, ſhowed us the nature of the blood. (1.) When freſh drawn, before it has time to putrefy, the blood, diſtilled with a ſlow heat, yields a *water* to the quantity of five parts in ſix of the whole maſs; which water has litle or no taſte or ſmell till you come towards the end of the operation, when it is proportionably more charged with a fetid oil. (2.) The reſiduum expoſed to a ſtronger fire, yields various alkaline liquors; of which the firſt, being acrid, fetid, and of a reddiſh colour, is uſually called the *ſpirit* of blood; conſiſting of a volatile ſalt, with ſome little oil, diſſolved in water to the amount of one twentieth part of the original maſs of blood. There is an acid obſervable in the fat, and likewiſe in putrid fleſh and blood. (3.) A little before, and together with the oil, that next aſcends in the diſtillation, dry *volatile ſalt* ariſes, and adheres in branchy fleeces to the neck and ſides of the glaſs; and this in but a ſmall proportion, leſs than an eightieth part of the firſt maſs. (4.) The next liquor is that called *oil* of human blood, which aſcends gradually thicker and heavier, and is at firſt yellow, afterwards black, till at laſt it reſembles pitch, being very acrid and inflammable, but in a ſmall quantity, about a fiftieth of the whole maſs. (5.) There now remains, in the bottom of the retort, a ſpongy inflammable coal or cinder of the blood; which, being kindled, burns away, and leaves aſhes behind. From theſe, by lixiviation with water, is obtained a *mixed ſalt*, partly ſea-ſalt, and partly fixed alkali, together with a ſmall quantity of fixed earth. This fixed ſalt is ſcarce the five hundredth part of the firſt maſs, and of this only one fourth part is alkaline: but being urged with the moſt intenſe degrees of fire, the whole ſalt affords ſome portion of *an acid ſpirit;* which we judge to ariſe partly from the ſea-ſalt in the blood, ſome of which is demonſtrable even in the ſpirit of blood; and partly from the vegetable kind of the aliments, not yet digeſted into an animal nature. For which laſt reaſon, an acid is procurable from the blood of graminivorous animals as well as from that of man. But the *earth*, ſeparated from the lixivium by filtration, will, perhaps, make about an hundred and fiftieth part of the original maſs; and contains ſome particles which are attracted by the loadſtone.

CXLIII. From the preceding analyſis of the blood, it evidently contains a variety of particles, differing in bulk, weight, figure, and tenacity; ſome watery, others inflammable, and moſt of them inclined greatly to putrefaction or to an alkaline nature. For the blood, in a ſound healthy ſtate, not injured by putrefaction, or too violent a degree of heat, is neither alkaline nor acid; but mild or gelatinous, and a little ſaltiſh to the taſte: yet, in ſome diſeaſes, it is ſharp enough, and comes near to a ſtate of pufrefaction; as for inſtance, in the ſcurvy, where it corrodes its containing veſſels; and in dropſies, the waters of which are often next to alkaline. But an alkaleſcent calx is found in the blood of inſects, which effervеſces with acids.

CXLIV. By viewing freſh blood in a ſmall glaſs tube by a microſcope, or by applying the ſame inſtrument, while it is yet moving in the veins of a warm living animal as a hen-chicken, or a cold one as a frog, we perceive in it red globules; which, doubtleſs, make that part called *cruor* or *craſſamentum*, mentioned in CXXXVII. If it be queſtioned, whether theſe are not rather lenticular particles of the ſame kind with thoſe obſerved by Leuwenhoek in fiſh, and lately diſcovered in our own ſpecies; we confeſs it is a point difficult to determine: nor have I ever made a ſufficient number of microſcopical experiments on thoſe globules which ſeem moſt denſe and conevx.

CXLV. The colour of theſe globules is red; and ſo much the deeper and more inclined to ſcarlet the ſtronger the animal is: and in the ſame proportion their number increaſes, when compared with the quantity of yellow ſerum. Their diameter is very ſmall, being between $\frac{1}{2000}$ and $\frac{1}{3000}$ of an inch. They are ſaid to change their figure into an oblong egg-like ſhape, which I could never obſerve with ſufficient certainty. They are alſo ſaid to diſſolve into other leſſer globules of a yellow colour, which I have neither obſerved myſelf, nor can eaſily admit.

CXLVI. From the red part of the blood, fibres are generated in abundance; from the ſerum, in ſmaller quantities. They are procured by pouring the blood into a linen cloth, and waſhing it gradually with a great deal of water, or by beating it with a rod. In quantity, they equal the 28th part of the whole maſs, Theſe are formed of the gluten, and are not generated in a living animal; ſeeing they are neither to be perceived by the microſcope, which ſo eaſily renders viſible the red globules, nor yet does their long thread-like figure ſeem adapted for receiving motion.

CXLVII. From the preceding experiments compared together, ariſes that knowledge which we at preſent have of the blood; namely, that the craſſamentum or cruor is compoſed of globules. The inflammable or combuſtible nature of theſe globules is proved from dried blood, which takes flame and burns; as alſo from the pyrophorus, which is generated from the human blood: and from theſe moſt probably ariſes thegreater part of the pitchy oil that is obtained from blood by the violence of fire.

CXLVIII. The ſerum of the blood diſtilled with a ſtrong fire, gives over almoſt the ſame principles with the cruor, viz. ſalt, oil, and earth. It yields, however, much more water, but no iron at all. Similar principles, but with a leſs proportion of oil and ſalt, are obtained from the aqueous humours prepared from the blood; as the ſaliva and mucus.

CXLIX. The exact maſs or quantity of blood contained in the whole body cannot be certainly computed. The weight of the maſs of humours, however, is much greater than that of the ſolids; but many of them do not flow currently in the circulation, as the glue or jelly that lodges in moſt parts, and the fat. But if we may be allowed to form a judgment from thoſe profuſe hemorrhagies[60] that have been ſuſtained without deſtroying the life of the patient, with experiments made on living animals by drawing out all their blood, joined with the bulk of the arteries and veins themſelves: from theſe principles, the maſs of circulating humours will be at leaſt fifty pounds; of which about 28 will be true red blood, current in the arteries and veins; of which the arteries contain only one fifth, and the veins the other four[61].

CL. Nor does the blood always contain the ſame, or a like proportion, of thoſe elements or principles above-mentioned: for an increaſed celerity, whether by laborious and ſtrong exerciſes, a full age, fever, or otherwiſe, augments the craſſamentum, with the redneſs, congealing force, and coheſion of the particles; and the hardneſs and weight of the concreted ſerum with the alkaline principles, are by the ſame means increaſed. On the other hand, the younger and leſs active the animal, and the more watery or vegetable the diet on which it is fed, the craſſamentum of the blood is proportionally leſſened, and its ſerum and mucus increaſed. Old age, again, leſſens the craſſamentum and the gelatinous part likewiſe.

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[60] The bodies of ſome women, who had died of an uterine hemorrhagy, have been ſent me, whoſe blood, to the quantity of 26℔, was found by chance collected in a veſſel: there appeared the greateſt paleneſs over the whole body, and I found the heart and large arteries and veins completely emptied. In the caſe of a female criminal who was executed, being of a plethoric enough habit, 24℔ of blood were collected, and all the veſſels found quite empty.

[61] Haller has changed this proportion, and indeed he has come nearer the truth; to wit, he has allowed four parts to the arteries, and nine to the veins.

CLI. From theſe principles, but with a conjunct conſideration of the ſolid fibres and veſſels, the different temperaments of people are derived[62]. For a *plethoric*

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[62] The theory of the temperaments of the human body, in the ſenſe commonly recived by phyſicians, and taught in the ſchools, the received diviſion of them into four ſpecies, and their repeated production from the different nature and mixture of the blood, ſavours too much of the ancient and particularly of the Galenical doctrine. I think there can be no doubt, that there are temperaments; and that the manner and rule which nature follows in man, and likewiſe perfect animals, may be obſerved in the performance of the corporeal and mental functions, in either preſerving or endangering the health and life, and in the exerciſe of moſt of the duties and affairs of life, and in the actions of the internal and external parts, which are more or leſs connected with the ſafety of the animal. If, therefore, one would wiſh to give any ſpecific name to this different relation and determination of the parts of our body, when once communicated with the ſyſtem in general, as you would do to any plant, or other particular natural body, and to keep the ancient denominations ſanguineous, choleric, phlegmatic, and melancholic, in preference to all others, he muſt be aware, that, neither the various habits nor temperaments of mankind can originate ſolely from the different nature of the blood, nor all be comprehended under theſe four modifications.

With reſpect to the cauſes of diverſity of temperament, there are many which co-operate. (1.) The various quantity, firmneſs, and ſentient faculty of the nervous ſyſtem, from the brain communicated to each nerve. I have always obſerved a choleric, and cholerico-ſanguineous diſpoſition, in all perſons having a large brain and thick ſtrong nerves, along with a great ſenſibility as well of the whole body as of the organs of ſenſe. Hence ariſes a ready apprehenſion of objects, and an increaſe of underſtanding and knowledge, and, owing to the compariſon of many ideas, an acute and entire judgement, which choleric perſons poſſeſs in ſo eminent a degree; but along with this condition of the nerves, they are exceſſively liable to grief and anger, when the body or mind is but ſlightly affected: and on this account medicines ſhould be cautiouſly given, and leſs doſes preſcribed to them. With a ſmall brain and ſlender nerves, I have obſerved the ſenſes more dull, and a phlegmatic or phlegmatico-melancholic torpor conjoined. Therefore they require from external objects ſtronger impreſſions upon the organs of ſenſe, and longer applied, if they are meant to leave *thoric* or *ſanguine* habit ariſes from an abundance of the red globules; a *phlegmatic* temperature from a redundancy of the watery parts of the blood: a *choleric* diſpoſition of the humours ſeems to ariſe from a more acrid, acid, and alkaleſcent property of the blood; as appears

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leave laſting effects: hence their judgment is frequently weak on account of the defect of ideas; and they ſeldom acquire any extenſive knowledge: but nature has compenſated theſe diſadvantages, by making them more able to undergo hardſhips from change of climate, life, or labour; they demand more powerful medicines and larger doſes. What a great difference in man and the cetaceous animals! (2.) The various degrees of irritability in the muſcular parts. For wherever you find a very delicate irritability, affected by almoſt every ſtimulus, and retaining laſting impreſſions, and at the ſame time acting with a certain celerity; in that caſe you cannot doubt of a choleric diſpoſition: hence that remarkable ſtrength in the muſcles of ſome perſons, which acts with ſo incredible quickneſs, diſpatch, and conſtancy. On the contrary, if you examine a phlegmatic perſon, you obſerve the contractile power of the muſcles languid, difficultly yielding to ſtimuli, unleſs powerful; ſince the muſcles of phlegmatico-melancholic men are long of being determined to motion, although ſtrongly excited, and finiſh it with an appearance of languor. (3.) Even a certain ſoftneſs is obſervable in all fibres and membranes, if you touch the body of a phlegmatic perſon; or a ſeeming hardneſs and dryneſs in melancholic habits: along with which particularities the phlegmatic join leſs elaſticity; whilſt in the melancholic there is a greater tone and contractile power. (4.) There is in the air, undoubtedly, a certain electrical principle; which being by reſpiration communicated in different ways with the body, imparts a natural tone to the fibres, occaſions a quicker motion in the veſſels, and increaſes and diminiſhes by turns the alacrity of the mind. But as this principle of atmoſpheric air does not prevail in equal quantity every hour of the day, all times of the year, and in every climate; ſo ſometimes, we feel an univerſal laſſitude, which ſuddenly ceaſes, the ſtrength of the body and mind being reſtored with a ſerene and elaſtic air; ſo in like manner all men do not equally abſorb this electric matter, which thus forms a remarkable diverſity of temperament. (5.) We ought too to combine with theſe the various nature of the blood from the proportion of the elements: and in fact, as greater ſtimuli in the blood excite the heart to briſker contractions; ſo a more acrid and copious bile may effectually promote the periſtaltic motion, and the abundance of mucus occaſion a tendency to lentor and frequent catarrhs.

appears from thoſe who live on fleſh, and on the human ſpecies, being ſo much fiercer and more paſſionate than thoſe who live on plants or on vegetable food. In the ſolid parts, a great firmneſs joined with an exquiſite ſenſibility, or nervous irritability, diſpoſes to

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Now, we ſee we have ſufficient cauſes, which from our birth may bring on, in the firſt growth of the parts of the body, an irrevocable determination to this or that habit or temperament. I therefore can ſcarcely admit a complete tranſmutation of temperament, which, during the exerciſe of theſe natural laws, could render a purely choleric perſon phlegmatic: But that ſome change may take place in temperaments, that violent attacks may be mitigated, that lentor, torpor, and liſtleſſneſs may be increaſed, I readily agree; and from the remedies by which ſuch a change may be produced, I form a ſecond claſs of the cauſes of temperaments. The chief are, (1.) A different kind of meat and drink. An animal diet adds a great ſtimulus to our ſtrength, invigorates our ſenſes, and ſometimes induces ferocity; as is evident from the Anthropophagi, carnivorous animals, wild beaſts and their whelps, and hunters, particularly if the abuſe of aromatics, wines, and medicines has ſupervened. Vegetables, on the contrary, increaſe the lentor of the fibres, weaken the ſtrength, diminiſh ſenſibility and irritability; in a word, induce a phlegmatic diſpoſition; in which potatoes have a wonderful effect. It would be of great conſequence to pay regard to this in the bringing up of children, viz. to invigorate the inertia of the mental and corporeal faculties by the uſe of animal food, but to temper the vehement paſſions, peculiar to choleric perſons, by uſing amongſt food a good deal of vegetables. (2.) The particular mode of education, examples. It need ſcarce be inſiſted on of what influence theſe are poſſeſſed, particularly in infancy: hence it happens, that whole nations are of one temperament. (3.) Climate, weather, native country. Rarely in an unſettled climate or country, in hot climates, or in moiſt countries, will you find in choleric perſons that alacrity of temper, agility of body, and quickneſs of underſtanding, which is ſo common in a ſerene and temperate heaven, and high hilly countries. (4.) The increaſe of knowledge. I have often admired that change which a ſtrenuous induſtry produces in ſome of the moſt dull men; ſo that with the increaſe of knowledge, they became of a more cheerful temperament. (5.) Abundance and want of neceſſaries, both in life and for the purpoſe of forwarding improvement. For this reaſon it may happen, that according to the diverſity of the form of government, whether under mild or more ſevere and tyranical laws, the temperament of the ſubject may be either lively or languid. (6.) The ſort of life itſelf, intercourſe with men, and public employment, may to a choleric habit; a leſs irritability, with a moderate denſity, to a ſanguine habit; and a leſſer degree both of denſity and irritability are to be referred to a phlegmatic temperament. There is alſo a kind of dull heavy temperament, in which there is the greateſt ſtrength

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may have a great ſhare in changing temperaments; ſince rarely after the 36th year of a man's life do you find the blood ſtill pure; and rarely a choleric perſon, who, after 50 years, has preſerved his former alacrity. It is difficult to ſay into how many ſpecies temperaments ſhould be divided, and what kind of character ſhould be aſſigned to each, according to nature and not conjecture. I doubt, I may not be more ſucceſsful than the celebrated Kaempfius and Gerreſhemius, as I exhibit the firſt lines only. The ſanguineous and phlegmatic temperaments, ſeem with various intermedia to comprehend all modifications. (1.) Then, the ſanguineous, which is inconſtant and not well ſpecified, is diſtinguiſhed by a vivid colour of the face; the veſſels are full; and hence for the moſt part they take ill with external heat; they are prediſpoſed greatly to inflammable diſeaſes; they have a great ſhare of ſenſibility and irritability, which all therefore indicate a deſire of pleaſure in this temperament, and the greateſt inquietude both of body and mind prevails: they are talkative; abide not long with any occupation; they are eaſily ſeduced, and contract an intimacy with every body; but they ſoon forget their friends, ſhowing a certain diffidence to all of them; they ſeldom meddle with affairs of any conſequence, and rarely acquire proficiency in the ſciences, unleſs in an advanced age. (2.) The ſanguineous-choleric enjoys a better mixture of cauſes; it has the ſupports of health and cheerfulneſs along with the former, but has perſeverence in common with the choleric. (3.) The choleric: Here you will always obſerve the body tender, though not emaciated and dry as is the caſe with the melancholic; the ſkin is of a whitiſh yellow, with red hairs; the balls of the eyes are of a moderate magnitude, the pupil being frequently dim; a penetrating lively countenance, ſometimes joined with a degree of ferocity; a quick pulſe; actions of the muſcles in walking, ſpeaking, and other reſpects very rapid; copious and acrid bile; hence an effectual periſtaltic motion, more frequent ſtools, a ready inclination to undertake any thing of conſequence, formed as if to command, and particularly fond of animal-food. (5.) The hypochondriac: An unhappy temperament, troubleſome to itſelf and others. Men of this ſort for the moſt part are ſubject to diſeaſes in the liver, have a yellowiſh appearance, always diſcontented, wonderfully tortured with envy and diffidence, and are called by ſome *cholerico-melancholic*. (6.) The melancholic have a dejected aſpect: The eyes for the moſt part ſmall, retracted, and winking, the hair black and ſtrength of body, joined with no great degree of irritability. In the melancholic, again, a weakneſs of the ſolids is joined with the higheſt degree of nervous irritation or ſenſibility. But you muſt be careful not to take theſe temperaments as the ſole and limited ſyſtems or claſſes of conſtitutions; which, in the courſe of nature, are found to be not only four, or eight, but are really diſtinct in numberleſs degrees.

CLII. The red part of the blood ſeems chiefly of uſe to generate heat, ſince its quantity is always in proportion to the heat of the blood. This being confined, by the largeneſs of the globules, within the red and firſt order of veſſels, hinders them from collapſing; and, in receiving the common motion of the heart by the greater denſity of its parts, it has a greater impetus, and ſets in motion the leſſer orders of humours. Nor is it improbable, that the heart is more ſtrongly irritated by the ponderous cruor of the blood. The globular figure of its parts, together

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and ſkin rigid, remarkable for its dryneſs and leanneſs; a ſmall and ſlow pulſe, ſparing and black bile, a ſlow periſtaltic motion. They indeed have quick perceptions, and ponder long; they ſubmit to toilſome labour with the greateſt patience, but finiſh it with incredible ſlowneſs: for the moſt part they pay no regard to time. They eaſily bear the diſadvantages of life; but when once their anger is excited, they love revenge. (7.) The bœotic or ruſtic joins a great ſhare of the ſanguineous temperament with the melancholic and phlegmatic. The body is luſty, full of juices, a ſmall irritability in its ſtrong muſcles, and ſome ſtupor in its ſmall nerves. Perſons of this ſort are capable of no education; and whatever they undertake ſavours of a low turn of mind. (8.) The gentle and mild temperament: this is compoſed of the ſanguineous, choleric, and phlegmatic. They are a good race of men, wiſhing well to all: in them we always perceive a calmneſs and ſweetneſs of manners; they ſtrongly hate a prating, noiſy loquacity: if devoted to ſtudy, they calmly undertake the taſk, anxiouſly ponder what they learn, and are capable of great proficiency. (9.) The ſlow phlegmatic is diſtinguiſhed by a ſoft and moſtly whitiſh ſkin, a very lax body, very prominent eyes, drowſy aſpect, a ſlow pulſe and walk: for the moſt part they ſpeak ſlow, are patient of the weather's inclemency and other people's affronts; born to obey; and on account of their ſlight irritability, difficultly enraged, and eaſily pacified again.

with their denſity, makes it eaſily pervade the veſſels; and the quantity of iron it contains, as well as of oil, perhaps increaſes its power of generating heat. And hence it is, that the red part of the blood being too much diminiſhed by profuſe bleedings, there follows a ſtagnation or leſſened motion of the humours in the ſmaller veſſels; whence fatneſs, and dropſy. By the ſame rule alſo a due proportion of cruor is neceſſary within the habit, to generate and repair new blood. For, by large hemorrhagies, we ſee the blood loſes its red or denſe nature, and degenerates into a pale, ſerous, or watery ſtate.

CLIII. The coagulable ſerum is more eſpecially deſigned for the nutrition of the parts, as will be hereafter more apparent, Chap. XXXI. The thinner juices ſerve various purpoſes; as the diſſolution of the aliments, the moiſtening of the external ſurface of the body, and ſurfaces of the internal cavities, to preſerve the flexibility of the ſolids, and conduce to the motion of the nerves, the ſight, &c. The ſaline particles ſeem proper for diſſolving the aliment, and ſtimulating the veſſels. The properties of the aërial part are not yet well known. The heat occaſions the fluidity, and is not eaſily raiſed to ſuch a degree as to coagulate the humours.

CLIV. Therefore health cannot ſubſiſt without a denſe and red blood, whoſe quantity too much diminiſhed cauſes a ſtagnation of the juices within the ſmaller veſſels; whence all parts of the body become cold and weak. Nor can life or health ſubſiſt without a ſufficiency of thinner juices intermixed with the red blood; ſeeing the cruor, deprived of its watery part, congeals, and obſtructs the ſmalleſt paſſages of the veſſels, and kindles too great a heat.

CLV. If it is aſked, Whether there be any difference betwixt the arterial and venous blood? we anſwer, That ſome difference ſeems to happen; the former having lately ſuffered the action of the lungs. But, in experiments, I ſcarce find any obſervable difference either in colour, denſity, or any other known diverſity.

ſity. Sometimes, however, I have found a moſt evident difference; for the bright red colour of the arterial blood ſeems to diſtinguiſh it from the duſky dark-coloured blood in the veins; but this, in the plain example of the hatching of a chicken, ariſes only from the deeper ſeries of globules in the thicker vein. But we have not ſufficient certainty of a difference in the blood of different arteries. However, the arterial blood is apparently of a more bright or ſplendid red; and having a greater degree of fluidity and proportion of watery parts, may ſo far differ from the venous darker-coloured blood. But to clear up this, farther experiments are requiſite.

CLVI. From one and the ſame maſs of blood, driven into the aorta, are generated all the fluids of the human body; which, from their affinity one to another, are reducible to certain claſſes. The manner in which they are ſeparated, ought to be accounted for by the fabric or mechaniſm of the glands themſelves. But we muſt firſt conſider what the blood ſuffers from its containing veſſels.

CHAP. VII.

Of the COMMON OFFICES *of the* ARTERIES.

CLVII. THE blood is driven from the left ventricle of the heart into the aorta; which takes its courſe firſt a little towards the right, and then to the left, in an arch that is very ſharply bent: and here the maſs of this purple fluid ſtrikes firſt againſt the right ſide, and is then reflected to the left ſide of the aorta; whence flowing in a vortical or whirling motion as much as that full veſſel will permit, it goes on through the arteries, with an alternate colliſion againſt, and repercuſſion from, their ſides. The aorta ſwells a little in bulk at the place where it proceeds from the heart.

CLVIII. The arteries are, in a living perſon, *always full of blood;* ſince the jet or ſtream that ſtarts from an artery, is not interrupted by alternate ſtops, while the heart reſts or relaxes itſelf, but it flows on in a continued thread: add to this, that the microſcope ſhows the arteries, in living animals, to be full, both in the their ſyſtole and diaſtole; nor can the circular fibres of the arteries ſo far contract themſelves as entirely to evacuate theſe tubes. Since, therefore, a new wave or column of blood is ſent into the arteries, already full, although it bear a ſmall proportion to the whole maſs contained in the arterial ſyſtem throughout the body, hardly ever exceeding two ounces; yet, by its immediate contact with the precedent wave or column, which moves ſlower as it gets farther from the heart, it conſequently drives the ſame forwards, lengthens the artery, and makes it aſſume a cylindric form, augments its diameter, preſſes the membranes cloſer to one another, urges the convex parts of the arterial flexures outwards, and cauſes their ſpiral waves to be more ſerpentine, as injections demonſtrate to us. This dilatation of the artery, whereby its light or capacity is changed from a leſs to a greater circle[f], is called the *pulſe;* the *diaſtole* of which is an expanſion of the artery beyond its natural diameter. This being the proper or characteriſtic action of life, reſults from the heart only, and is in nowiſe natural to the arteries left to themſelves. Hence when the motion of the heart is intercepted, whether by aneuriſm, ligature, or otherwiſe, there is no pulſation of the arteries to be felt; and hence there is a ſudden ceſſation of the pulſe, by a wound through the heart, in a living animal. But the artery is proportionally more dilated, as the wave of blood flows on before more ſlowly, and the more the velocity of the new wave exceeds that of the former one.

CLIX. The *ſyſtole* or contraction of the artery follows the dilatation of it. For the heart having emptied itſelf, and removed the ſtimulus of the blood, comes into a ſtate of relaxation and reſt. But the artery, at this ſame time, by its innate elaſticity and contractile power reſiding in its circular fibres, irritated likewiſe by the ſtimulus of the blood, contracts itſelf, and expels as much blood as ſerved to dilate it beyond its mean or middle diameter: this quantity of blood is either forced into the ſmaller and ſcarce-beating arteriolæ, or into the veins, as the ſemilunar valves of the aorta oppoſe the return of the blood in the part of that veſſel through which it has juſt now paſſed. So ſoon as the artery has freed itſelf from this wave or column of blood, being no longer ſtimulated by diſtention, it directly collapſes by its own proper contractile force, and is now again ready to yield to a new wave or column of blood ſent into it from the heart; whence follows a repeated diaſtole.

CLX. That the arteries thus contract, and, by that force, propel their contained blood, is proved evidently from their ſtrongly contractile nature; from the apparent diminution of the diameter or dilatation they receive from the heart; from the evacuation that follows, by the proper force of the artery itſelf, driving out all the blood that is contained in the lateral branches betwixt two ligatures; from the return of the blood to the heart through veins whoſe artery is tied, which therefore the heart has no ſhare in propelling; from the wave of blood being greateſt when the heart is in its diaſtole, as obſerved by ſome eminent anatomiſts; from the ſtrength with which the blood is ejected from the tied aorta below the ligature; from the evacuation which the arteries make of their contained blood even after death into the veins, whereby theſe latter appear much fuller than the arteries; and, laſtly, from the conſiderable ſaltus of blood that iſſues from a large artery in an animal even after death, mounting to the height of two feet: to which add, the convulſive contractions of the animal in which the artery is thus wounded, and the remarkable cloſings of the mouths of divided arteries in wounds, and a ſphacelation of the limbs from an oſſification of the artery; whence the veins become diſtended.

CLXI. The mean ſwiftneſs of the blood's motion being diminiſhed in the time of the heart's ſyſtole, but increaſed during its diaſtole, is ſuch as carries it through a ſpace ſomewhat leſs than one foot in the ſpace of a ſecond of time; and the conſtant plenitude of the arteries renders it impoſſible for us to perceive any ſucceſſion in the pulſes of different arteries; whence all the arteries of the body ſeem to beat at one and the ſame inſtant, whilſt the heart ſtrikes againſt the breaſt: and yet there is certainly a ſucceſſion in the ſyſtole of the arteries, by which the aorta ſeems to contract in the ſame order ſucceſſively, as it is filled by the blood expelled from the heart; ſo that the part of the artery next the heart is firſt conſtringed, and thence, gradually, the arterial contracting force proceeds to the extremities. An inſtance of this we have in the inteſtines; and the ſame is evident to the eye in inſects, who have a long fiſtulous and knotted heart, manifeſtly contracting in a ſucceſſion from the beginning to the end. But the mind cannot diſtinguiſh the leaſt points of time, which are the meaſures of this ſucceſſion, and amount only to a few thirds of a ſecond.

CLXII. If it be aſked, Where this pulſation ends? we anſwer, In the leaſt arteries, and cylindrical originations of the veins. We have already mentioned the velocity with which the blood comes from the heart. But that velocity continually decreaſes. Certain we are, (1.) That the lights or ſections of the arteries, compoſed by the aggregation or ſum of their tranſverſe ſections, as they divide farther in their courſe from the heart, greatly exceed that of the aorta; ſo that ſince the ratio, or leſs proportion of the trunks to their branches, continually diminiſhes as they make leſs ramifications, and this in a variable or uncertain proportion; the difference of that ratio or proportion will be the greateſt betwixt the light of the aorta at the heart, and the ſum of the ſections of all the ſmall arteries, where they are leaſt, in the extreme parts of the body. Again, (2.) The proportion of the arterial membranes or coats in thickneſs, with reſpect to their bores or capacities, is greater as the arteries grow leſs; and is largeſt in the leaſt of them, which tranſmit only one globule at a time. The truth of this is proved from anatomy, and the forcing of air into the arteries, by which they burſt always more difficultly as they are leſs; and from the calculation itſelf, by which the magnitude of the leaſt arteries is determined from the globules diſtending their two ſemicylindric membranes. Add to this, (3.) The friction of the juices through the leaſt veſſels, inflected and meeting together in angles; which friction, even in the moſt fluid water, running through long pipes that are ſingle, and in a direct courſe, greatly diminiſhes the velocity, and more in proportion as the tube is of a leſs bore; while again, as the artery is leſs, there are a great number of globules rubbing and grating againſt its membranous converging ſides. And by the conical figure of the artery, it happens, that the broader wave of blood, coming from the trunk, is reſiſted in its paſſage through the narrower branch, and ſo muſt diſtend it by force. But moreover, (4.) The *inflections and folds*, or plates of the veſſels, greatly ſlacken the blood's motion; ſince always ſome part of the impelling force is ſpent and loſt in removing the convex parts of the folds, and changing the figure of the inflected veſſel. The angles likewiſe take off more from this force in proportion to their acuteneſs, or the more they recede from a ſtraight line. Laſtly, (5.) A conſiderable allowance muſt be made for the great viſcidity or tenacity of the blood itſelf; ſince, by reſt only, it directly hardens into clots; and ſince it is from the circulatory motion only of the blood, that this mutual attraction of parts is overcome, ſo as to hinder it from adhering to the ſides of the arteries; for ſo we find it adhere in anueriſms and wounds of the arteries, or elſe the globules clot together, as we ſee uſually after death. From all which conſiderations, you will obſerve, that the blood meets with the greateſt retardation in its courſe in the leaſt veſſels. And the oppoſition it meets with in the branches leſſens the velocity of the blood alſo in the trunk: the oppoſition of torrents of blood to one another in the anaſtomoſes of veſſels alſo deſtroys ſome parts of its motion. We may eaſily perceive the amounts of this retardation will be very conſiderable, although it be difficult to eſtimate it juſtly. In the larger trunks the blood of a living animal flows with the rapidity of a torrent: but, in the leaſt branches, it creeps along very ſlowly; ſo that in theſe it begins to put on a ſtate of coagulation. It is alſo well known to ſurgeons, that a ſmall branch of an artery near the heart or aorta bleeds more dangerouſly than a much larger one that lies at a greater diſtance. The weight of the incumbent atmoſphere, of the muſcles and fleſhy parts lying above the artery, and the contractile power of the veſſel itſelf, make a reſiſtance indeed to the heart; but do not leſſen the velocity of the blood, ſeeing they add as much in the diaſtole as they diminiſh in the ſyſtole.

CLXIII. It is certain, however, from inciſions made in living animals, that the ſingle globules of blood, which move ſeparately in the ſmall veſſels, do not loſe ſo much of their velocity as, by calculation, they ought to do. We muſt therefore aſſign ſome cauſes by which this power, deſtructive of the blood's motion, is leſſened. And, in the firſt place, it is certain, that the lights of the branches do not bear ſuch a proportion to the trunk in the ſmalleſt veſſels; their great ſmoothneſs diminiſhes the friction. The facility likewiſe with which the blood flows through the veins, expedites its paſſage through the little arteries, which immediately communicate with theſe veins. No great help is to be expected from conſidering the effect of ligatures or the weight of the blood, which is capable both of diminiſhing and accelerating the motion; nor can we ſuppoſe that in live animals a great effect depends upon the force of the nerves. The power of derivation, whatever that is, and the motion of the muſcles, are capable of producing a new velocity.

CLXIV. The pulſe therefore enſues, becauſe the anterior wave or column of blood moves on ſlower, while the ſubeſquent or poſterior wave comes faſter; ſo that the preceding is an obſtacle to the conſequent blood (CLVIII.). But ſince the force of the heart weakens as the blood goes on, and the contractile power of the arteries increaſes, therefore the diſproportion of celerity betwixt the antecedent and conſequent waves or columns of blood coming from the heart, will be continually leſſening with reſpect to the blood that is urged on by the contraction of the ſmaller veſſels, till arriving at a part where there is no exceſs or difference, it will there ceaſe to make any pulſation of the artery; becauſe here the anterior and conſequent blood flow evenly, or with the ſame celerity. But this place of equality in motion, cannot be in the larger and more conſpicuous arterial branches: for in them the wave, laſt coming from the heart, moves quicker than what went before; as is evident from the inflammatory pulſation of them, eſpecially in the ſmall arteries of the eye. But, in the leaſt red arteries, the pulſe at length begins to vaniſh. This is evident from the equable motion of the blood, often ſeen by a microſcope through the arteries of a frog. In the larger veſſels, however, ſuch as may be about the ſixth part of a line in diameter, the pulſe is perceptible. But in the leaſt veins viſible to the eye, there is no ſenſible pulſation or accelerated motion of the blood, whilſt the heart contracts, demonſtrable either by the microſcope or any other experiment.

CLXV. Even in the veins, the blood preſſes againſt their ſides, as appears from the furrows hollowed out of the bones, and the ſwelling of the veins on being tied. If it be aſked, Why the veins do not beat? (for we do not allow that to be a pulſe which happens from reſpiration, from the rejection of the blood from the right auricle, or from the muſcular part of the vena cava); the reaſon of this ſeems to be, that the blood, immediately on its leaving the heart, is more retarded in its motion than when it paſſes into the ſmalleſt veſſels. Hence, the ſhort ſpace of time by which the velocity of the laſt wave exceeds the foregoing, is greateſt at the heart, and grows gradually leſs, till it at laſt totally vaniſhes. This is illuſtrated by the experiment, in which a pipe, fixed in a leathern tube, and driving forth water in a continual, but ſtarting ſtream, does, by a ſponge fixed round the mouth of the ſaid tube, cauſe the water to iſſue forth in an even ſtream, without leaping through the ſponge: and the ſame is evident from another experiment, in which the ſame thing happens, by injecting the meſenteric arteries with an alternate impulſion of water; for then the water flows out through the veins in one continued even ſtream.

CLXVI. The *pulſe* is therefore the meaſure of the powers which the heart ſpends on the blood; becauſe it is the immediate and full effect of thoſe powers. Hence, all things conſidered as alike, the pulſe is *ſlow* in the moſt healthy people, where there is no ſtimulus, nor any unnatural reſiſtance to cauſe the effect of a ſtimulus, but the heart is at liberty to ſend forwards the blood with eaſe. You muſt except thoſe caſes where there is ſome obſtacle, by which the blood is prevented from entering the aorta. For this reaſon the pulſe in aſthmatic people is ſlow: the ſame thing alſo happens from a debility or inſenſibility of the heart, which the uſual ſtimulus is not capable of exciting to contraction. A *large* pulſe is cauſed by fulneſs of the artery, joined with a ſtrong force of the heart; a ſmall pulſe by the emptineſs of the artery, and a leſſer wave of blood ſent from the heart. A *hard* pulſe denotes ſome obſtacle or ſtimulus; or elſe that the heart's force is increaſed with a greater thickneſs of blood, or a greater rigidity of the artery. A *quick* pulſe denotes ſome ſtimulus, obſtacle, or greater ſenſibility or irritability of the heart. It is beſt felt where the artery lies expoſed bare to the touch, upon ſome reſiſting bone; but obſtructions ſometimes render the pulſe perceptible, where it is never ſo naturally.

CLXVII. The pulſe is ſlower in animals as they are larger or more bulky; becauſe the heart is proportionably bigger in the ſmaller than in the larger animals, and, as well as the other parts of the body, is more irritable in the former than in the latter; and becauſe the heart is obliged to drive the blood to a greater diſtance; whence the reſiſtances or frictions in the more bulky ſeem to be increaſed more than the force of the heart. Hence, ſmall animals are more voracious; and large ones, as the whale and elephant, eat leſs. The pulſe of a healthy perſon riſing in the morning, beats 65 in a minute; but, after the fatigue of the day, it will beat 80 in that time; and again, by the night's reſt or ſleep, it will become gradually leſs frequent, till in the morning you will find it returned to its primitive number of 65. For the motions of the muſcles, and actions of the external and internal ſenſes, the warmth of the atmoſphere, and the action of the aliments taken into the ſtomach, urge the venal blood on to the heart, which being thereby oftener ſtimulated, makes more frequent contractions. This is the cauſe of thoſe paroxyſms or fits of increaſe obſervable in all fevers towards the evening. For ſleep not only retards the motion of the blood, but of all the other humours and actions in the body whatever.

CLXVIII. A frequent pulſe is different from a ſwift one; and it is poſſible for the pulſe to be at the ſame time ſwift and unfrequent. But it is difficult to obſerve a ſwift pulſe. The frequent pulſe is what is commonly called a *ſwift* one, It takes place in children, and becomes afterwards ſlower in perſons as they grow older. The ſalient point beats 134 in a minute: new-born infants have their pulſe 120 in that time; and from thence down to old age it grows ſlower, to 60 in a minute. A feveriſh pulſe begins from 96 per minute; and we count the pulſe has but a moderate celerity in fevers, or laborious exerciſes of adult perſons, if it does not exceed above 110 or 120 in a minute: but it is exceſſive at 130 or 140, with which number people ſeldom recover; nor have I ever obſerved it exceed that number. The pulſe beats ſlower in winter, and quicker in ſummer, by about 10 ſtrokes per minute; and under the torrid zone, it grows quicker to 120[63]. The different paſſions of the mind variouſly accelerate, retard, and diſturb the pulſe. Whatever obſtructs the circulation is alſo found to accelerate the pulſe; not from the laws of hydroſtatics, or on account of the canal being made narrower, nor from the action of the ſoul; but only the heart being with more difficulty freed from the ſtimulating contracts itſelf more ſtrongly, and at ſhorter intervals. An irritation from an acrid blood is the cauſe of the frequent pulſe in fevers.

CLXIX. Through the leaſt veins the blood moves on very ſlowly, partly by force of the heart, and partly by the contractile force of the arteries. The firſt is proved by a renewal of the motion of the blood in perſons drowned; where, merely by exciting the action of the heart, the whole maſs is again propelled. But the contractile force of the artery is proved by what is ſaid (CLX.). But after death the blood continues to move, in part, alſo by its own gravity, and by the elaſticity of the air generated or extricated by putrefaction.

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[63] I obſerve a wonderful difference in the pulſe, as it depends upon temperament: for in a ſanguineous and choleric habit the pulſe is more frequent, let the age, ſex, and ſtate of mind be what it will; in a phlegmatic and melancholic perſon, it is ſlower. But the whole doctrine concerning the pulſe, though you even ſlightly eſteem ſome of the too ſubtile diſtinctions of the French, and the prognoſtics in diſeaſes reſulting from theſe, is, however, much indebted in the preſent age to the induſtry of ſome of the moſt reſpectable men; ſome of whom Haller has mentioned, and among whom Gruner, Stedman, and others, may alſo be ranked.

CLXX. But the blood moves on faſter in the larger veins. For whenever the impelling powers remain ſufficient, and the conveying ſmall veſſels are rendered narrower, the motion of their contained fluids muſt of courſe be accelerated; ſince the ſection of the venal trunk is much leſs than that of all its branches, in the ſame manner as that of an artery is leſs than the ſum of the branches into which it divides. Therefore if the motion of the venal blood loſes nothing in its way, the proportion of its celerity in the vena cava, to its celerity in the veins of the thirtieth diviſion, will be thirty times greater in the former, in proportion as the conjunct lights of all the ſmall veins exceed the light of the cava. In like manner, too, the friction or attrition of the blood in the veins, and its contact with their ſides, diminiſh.

CLXXI. But ſince the blood moves thus ſlowly in the leaſt arterial veſſels and incipient veins, and as the weight of the blood itſelf, in many places wonderfully hinders its return to the heart, while, at the ſame time, the very thin coats of the veins have but little contractile power to be expected from them; therefore nature has uſed various precautions, leſt, from the ſlowneſs of its motion, it ſhould any where ſtagnate or concrete. To obviate this, ſhe has ſupplied the veins with more watery vapours and fluxile lymph, than ſhe probably ſent by the arteries, if we conſider the great exhalation that is made from the arterial blood in the lungs.

CLXXII. She has, therefore, likewiſe placed the veins near the muſcles, that by the turgeſcence or contractions of the latter the veins may be preſſed; and ſince any preſſure upon the veins muſt be determined towards the heart (LXIII.), therefore all this force muſt be entirely employed in accelerating the return of the blood to the heart. From hence proceeds that wonderful quickneſs of the pulſe (CLXVII), heat, and redneſs of the body, with a ſhort and laborious breathing, that attend muſcular motions or violent exerciſes.

CLXXIII. Moreover, thoſe muſcles, which conſtantly urge or preſs violently the contiguous viſcera on all ſides that are contained in any of the common cavities, do all of them powerfully promote the return of the venal blood to the heart. Such an effect has the conjunct preſſure of the diaphragm with the abdominal muſcles, in reſpect to the abdomen. Laſtly, the pulſations of the arteries, which run every where contiguous and parallel to the ſides of the veins, have no inconſiderable effect in promoting the return of the venal blood; ſince, as we have before ſhown, any impulſe acting on the veins can determine their blood to the heart only.

CLXXIV. To theſe is added a force not yet ſufficiently known, by which the blood is brought from a place where it is more compreſſed to one more lax, and where it meets with leſs reſiſtance. In this matter alſo reſpiration is of great efficacy; in which the motion of the blood into the lungs, when relaxed, is accelerated by the power of derivation from all parts of the body: and again, in exſpiration, it is driven into the trunks of the veins in the head and abdomen. Hence the ſwelling of the veins, and likewiſe of the brain, in the time of exſpiration. The circulation is not indeed aſſiſted by theſe cauſes, but the blood is agitated and preſſed. The anaſtomoſes of the arteries contribute to the ſame end; for they render the paſſage of the blood more eaſy from thoſe places where it is obſtructed to ſuch as are more free.

CLXXV. By theſe means, the blood in a healthy perſon, uſing ſufficient exerciſe of body, moves on with ſuch a velocity, as ſuffices to deliver as much of the purple fluid in every pulſe by the vena cava to the heart, as is equal to what is ſent out by that great artery the aorta. But reſt or inactivity of body, and a weakneſs of the contracting fibres of the heart and other muſcles, frequently render this motion of the venal blood more difficult. Hence follow the varices and the piles in women with child; which latter is much occaſioned from the deficiency of valves in the vena portarum. And from hence ſpring even the menſes themſelves. And when the veins too ſlowly return their blood to the heart, the ſubtile vapours, being thus unable to return to the heart, are obliged to ſtagnate; whence proceeds that frequency of œdematous and pitting ſwellings of weak people.

CLXXVI. The time in which an ounce of blood, ſent out from the left ventricle of the heart, returns to the right, and which is commonly reckoned the time in which the greater circulation is performed, is uncertain, and different in every different portion of the body. If, however, you want to know about the ounce of blood propelled in that quantity, which we have mentioned, the amount of it will be about 7½ ounces in an hour with 4500 pulſes; and the amount of the perfect circulations will be about 23½.

CLXXVII. The effects which follow from the motion of the heart and arteries upon the blood are various, which may be deduced and eſtimated from the cauſes themſelves of thoſe effects, if we compare the blood of a living and of a dead animal, that which is healthy with that which is diſeaſed, and that which is inert or too little moved with that which circulates too ſwiftly. For we obſerve, that, in the living, the blood is, (1.) Conſiderably warm or hot. (2.) It looks red, with a ſort of purple florid hue. (3.) It ſeems to be homogeneous or uniform, and alike in its parts; though they are really mixed and of different principles. (4.) It is made up almoſt entirely of globules. (5.) It flows very readily through the leaſt veſſels: From whence being drawn, (6.) It exhales a volatile vapour, which we have already deſcribed particularly. In the dead animal which has not yet begun to corrupt or putrefy, we obſerve, (1.) That it has loſt a great deal of its redneſs. (2.) That it ſeparates into a more denſe and a more thin ſubſtance. (3.) That it exhales no vapour. (4.) Being drawn out from the veins, it congeals either all or the greateſt part. But even in the living animal, when very weak, where there is ſome pulſe or reſpiration, though ſmall, we find the blood cold, even to a conſiderable degree. If, again, you compare the blood of a human perſon, unactive both in body and mind, with the blood of one that is addicted to violent exerciſe, you will obſerve the latter has, (1.) A greater heat. (2.) A more intenſe redneſs. (3.) A ſubſtance more compact, and ſpecifically heavier. And, (4.) The volatile parts more abundant. All which appearances ſeem manifeſtly the effects of the motion of the heart and arteries, ſince they proportionably increaſe and diminiſh with that motion, and diſappear when that ceaſes.

CLXXVIII. That we may underſtand the manner in which theſe appearances are produced in the blood, we muſt conſider what are the effects of the heart impelling the ſame, and of the arteries alternately compreſſing and urging it forward. And firſt we ſee, that the heart drives the blood into the arteries with a very great celerity (CXXIII.) With a confuſed or vortical motion, the heart thus throws the blood into the crooked or inflected arteries, in ſuch a manner, that the right globules, expelled through the opening of the aorta, ſtrike againſt the left ſide of the artery; from whence being repelled, they incline towards the right ſide, whereby all the particles of the blood are agitated with a confuſed or turbulent and whirling motion. The blood thus impelled againſt the flexile and curved ſides of the arteries, of neceſſity dilates or diſtends them into a greater convexity; and, laſtly, in the ſmaller veſſels, capable of receiving only one or a few of the blood-globules, all the ſaid globules come ſo intimately into contact with, and grate againſt, the ſides of the ſaid artery in all their points, that they are even obliged to change their figure in gaining a paſſage into the veins.

CLXXIX. But the arteries, by their elaſtic force, reacting upon the impinging blood, repel the ſame from their ſides towards the axis of the light or capacity; and at laſt tranſmit every ſingle particle of it through the circular mouths of the leaſt veſſels, by which the arteries and veins join together.

CLXXX. There is, therefore, a moſt prodigious degree of friction, as well from the blood globules upon the ſides of the arteries, as from the arteries themſelves contracting round the blood; to which add, the attrition of the particles of blood againſt each other by the confuſed and vortical motion with which they are propelled. The effects of this friction may be computed from the viſcid and inflammable nature of the blood itſelf, from the narrowneſs of the veſſels through which it runs, and from the ſtrong impulſe of the heart, joined with the powerful reaction of the arteries; to which add, the weight of the incumbent parts raiſed by the force of the arterial blood. This friction generates a fluidity in the blood, by perpetually removing the points of contact in its globules, reſiſting their attraction of coheſion, mixing together particles of different kinds, which become more fluid upon mixture, as we have an inſtance in oil when triturated with water. It alſo augments the ſphericity of the particles, by breaking off their protuberances and little branchings. But even theſe very ſmall particles themſelves, which are broken off from the large particles of the blood, put on a round figure by their friction againſt the ſides of the canals, and by their rotatory motion: By deficiency in theſe particulars the blood coagulates in the veſſels before death; and hence the loſt fluidity of the blood is again reſtored, by recovering the motion of the heart, as we are taght by experiments made on living animals. It is a queſtion, whether this motion of the blood, and the denſity proceeding from it, is the cauſe of the red colour of the blood[64], ſee-

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[64] Even the premiums have been unavailing, which have been propoſed by ſome of the moſt famous boards of ſcience, for diſcovering the

ing the redneſs is in proportion to the denſity, and increaſes or decreaſes from the ſame cauſes. This ſeems to ariſe from a mixture of the ferruginous with the oily part of the blood.

CLXXXI. We may alſo aſk, whether the heat of the blood does not alſo proceed from its motion[65]? ſeeing we obſerve heat to ariſe from the motion of all kinds of fluids, even of air itſelf, in our experiments; but much more does this attrition produce heat in the inflammable animal juices, which are denſer than water, and compreſſed with a conſiderable force by contractile and converging tubes. Is not the truth of this ſufficiently evinced, by the blood's being warm in thoſe fiſh which have a large heart, and cold in ſuch as have a ſmall one? the generation of

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the true cauſe of the blood's redneſs. The primary cauſe has been ſuppoſed to be iron, from the experiments of Menghini and Stormius; and likewiſe the influx of the aërial principle according to Prieſtley; and an inflammable ſubſtance, conjoined with the aërial acid, according to Weigel and other chemiſts. opinions. Every hypotheſis has its own difficulties to encounter. If we could demonſtrate ſo great a quantity of iron in the blood as is requiſite to tinge 30℔, and to produce ſuch an appearance of redneſs as blood exhibits, I would without heſitation aſcribe the cauſe to it: but there is too ſmall a quantity; nor does the frequent uſe of chalybeates favour the hypotheſis. The more probable opinion, therefore, is, that ſome inflammable principle, ariſing from the air and our aliments, along with ſome metallic matter, mixed by the vital powers of the body, is the efficient cauſe. Perhaps ſome other cauſes are yet concealed. May any light be diſcovered from the opinion propoſed by Hewſon about the efficacy of the ſpleen?

[65] Although it be eaſier to ſhow, that animal heat is not produced properly from the friction of the fluids upon the veſſels, than to ſubſtitute a more ſatisfactory and probable explication, my own reading and experiments, nevertheleſs, will not allow me to favour this theory. On the contrary, I am perſuaded, that the various ſtates and quantity of animal power in the nervous ſyſtem, the air's quality and acceſſibility, according to the freedom of reſpiration, to our lungs, the motion of the muſcles in their different degrees of increaſe and excitement, conjunctly with the progreſſive motion of the blood, not only produce the vital heat, but diſperſe it, when once produced, through all the body, in proportions which vary according to the greater or leſs ſupply of veſſels in the different parts.

of heat being in proportion to the ſize of their bodies: from the more intenſe heat of birds that have a larger heart, and more frequent or quick pulſations? from the increaſe of animal heat, that enſues from exerciſe of all kinds, and even from bare friction of parts? from the congelation of all the humours of the human body in a certain degree of cold, in which a man grows ſtiff, though he yet retains ſome warm blood and is alive? and from the coldneſs of ſuch people as have their pulſe weak and obſcure? Nor does the heat at all ariſe at firſt from any degree of putrefaction in the blood, ſeeing the humours themſelves, when left at reſt, generate no heat. Nor muſt we explain an evident appearance from the action of ſuch an obſcure being as the *vital power;* and though ſometimes the heat may be greater when the pulſe is ſlow, and leſs when it is more frequent, the difference may ariſe from the different diſpoſition of the blood, from the different denſities of the veſſels, or the increaſe or diminution of perſpiration.

CLXXXII. The ſame cauſe alſo hinders putrefaction, by not ſuffering the inteſtine motion to be diminiſhed, and by diſſipating ſuch particles as have already begun to be corrupted.

CLXXXIII. But the different natures of the ſeveral particles themſelves, which conjunctly make up the maſs of blood, are the cauſes by which, from one and the ſame impetus of the heart, different effects or conſequences are produced in different particles of the blood: Namely, thoſe particles move quicker, whoſe greater denſity makes them receive a greater impetus, and whoſe apt figure or leſs extended ſurface makes them meet with leſs reſiſtance in the fluid in which they move. Thoſe alſo are driven along more ſwiftly, which, either from their weight, or from the direction in which they paſs out from the heart, are urged chiefly into the axis of the veſſel. Thoſe again will ſtrike againſt the convexities of the flexures in the arteries, which have the greateſt projectile motion;

while the other parts of greater bulk and tenacity, having leſs projectile motion, will move ſluggiſhly along the concavity of the veſſel. And in this manner is the blood prepared or diſpoſed for the ſeveral ſecretions.

CLXXXIV. The *ſyſtole* of the arteries renders the parts of their contained fluids more denſe or compact, while they contract round the blood as round a ſolid obſtacle; which being in ſome parts viſcid and compreſſible, they drive and expel the more liquid parts into the lateral mouths or ducts, at the ſame time increaſing the points of contact betwixt the globules themſelves, combining their more large and denſe ſpherules, and compacting the flat particles into denſer bodies. But the denſity of the blood is partly as the number of globules, and partly as the denſity of the materials whereof theſe globules are compoſed.

CLXXXV. Moreover, the mouths of the leaſt veſſels pervious to only one globule at a time, ſeem to be a ſort of moulds to figure and break off the angular eminences of the particles in the blood, and bring them to a ſpherical figure; which at length they put on, and change into perfect ſpherules. Laſtly, from hence ariſes the denſity of thoſe particles; ſince, of all figures, ſpheres contain the moſt within a given ſurface.

CLXXXVI. The *reticular* diſtributions and inoſculations of arteries remove any danger of obſtruction; ſince in any part of the artery where the blood cohering begins to form an obſtruction, a contrary flux is admitted, by which the obructing matter is repelled to a larger part of the trunk; and thus betwixt the reflux and the direct torrent of the blood, the ſaid matter is broken and attenuated. This mechaniſm alſo ſupplies the deficiency from an irremovable obſtruction or the loſs of a veſſel, by cauſing a greater diſtenſion or enlargement of the next adjoining or anaſtomoſing veſſel; as is proved by experience in ſurgery, after tying and cutting a great artery. The colliſion of theſe oppoſite torrents of blood take ſomething from its velocity; and the reticular diſtribution augments the friction of the globules.

CLXXXVII. As the quicker motions of the blood in the trunks conduce to ſanguification, ſo the ſlower motions of it, in the leaſt veſſels, have their effects towards the ſecretions. In the larger arteries, we ſee the different particles of the blood are whirled about amongſt each other with a rapid and confuſed motion; but, in the leſſer ramifications, the progreſſive motion of the blood being diminiſhed, the more looſe colourleſs particles depart laterally from the more denſe and red globules, while the latter keeping on their courſe more firmly along the axis of the veſſel, expel the former laterally and to the circumference. Thus the attractive powers of the particles in the blood increaſe as their progreſſive motion abates; hence, the oily or fat particles are drawn one to another, and go off by the open lateral ducts that lead to the cellular ſubſtance; which particles we know are both groſs and ſluggiſh: and again, other thinner juices are ſent off through lateral branches of a much ſmaller orifice, till at length little more than the red blood alone remains to paſs through the evaneſcent artery into the incipient vein. But all theſe particulars, by which the blood is diſpoſed for the ſecretions, we ſhall conſider diſtinctly in the following chapter.

CHAP. VIII.

Of the SECRETIONS.

CLXXXVIII. THE claſſes or tribes of humours which, being depoſited or ſtrained off from the blood into other veſſels, are ſaid to be *ſecerned* or *ſecreted*, ſeem reducible to four : of which

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[66] The diverſity, in fact, is great of the fluids prepared in the bodies of animals, which is evident in their quantity, nature, and elements, production, uſe, ſucceſſion, and changes. The tears, ſaliva, mucus, fat, oil, ſweat and perſpiration, both external and in-

which the *firſt* includes all the viſcid and lymphatic juices, which are coagulated by a heat of about 150 degrees, by alcohol, and by acids; although generally, in the living animal, they are capable of flying off in form of a vapour, and after death are within the ſame

veſſels

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internal, into the cavities and inteſtines; the urine, gaſtric and inteſtinal fluids; the bile, the lubricating liquor of the joints, the ſemen, the juice of the proſtate gland, the lymphatic juices, milk, chyle, and other liquors, whoſe nature is not yet ſufficiently known, as that in the gall-bladder, ſecreted from the cellules of the internal coat, and ſome others: In all theſe, that ſome agreement ſubſiſts, but in others the greateſt difference, is certain. But Haller's diviſion into four claſſes is not perfectly conſonant with truth; for more marks of difference are given, though I do not ſee the diſtinct limits. Chemiſtry ſhows certain particles in ſome, which others clearly want; there are however ſeveral chemical combinations ſo ſtrongly united, that the gentle actions in our body are ſcarcely conſiſtent with them. For the moſt part we ought not to truſt thoſe parts which we obtain by the operation of fire, and which are in our humours under clearly a different nature. However, chemiſtry has enabled us to reduce the animal humours into ſome certain claſſes. They ſeem capable of being divided into three; the pure, mixed, and dubious.

The firſt claſs contains clearly, (1.) Thoſe merely aqueous, and as if excrementitious, whoſe ſecretion is always copious; and they contain, along with a great quantity of water, ſome oil and ſanguineous exhalation, mixed with a little earth. Nature often wonderfully differs in the place of ſecretion, that almoſt always one may be ſubſtituted to the other with the greateſt ſafety to health; but they are often determined to the internal cavities, as in dropſy, to the great danger of life. To this chiefly belongs that part of the tears which ariſes from the exhaling veſſels, the urine, perſpiration, and ſweat. Theſe liquors never are ſecreted from true glands, but from the veſſels continued. (2.) The ſalivary liquors: With much water they join a ſaponaceous ſolvent principle; and although no pure mucus is mixed, they always ſhow ſome tenacity, and poſſeſs a wonderfully aſſimilating power: hence their primary uſe in the preparation and digeſtion of our aliment; but at the ſame time, the greateſt power of contaminating and infecting it, as in contagion, kiſſes, biting, &c. I refer to this the true ſaliva effuſed into the mouth, the pancreatic juice, the gaſtric and inteſtinal liquor, the part of the tears which comes from the lachrymal gland. Theſe are all ſecreted through true conglomerate glands furniſhed with an excretory duct. (3.) The mucus. Mucus is a very natural fluid, nowhere produced unleſs in the inner ſurface of the body, ſecreted from true follicles or cryptæ,

forming

veſſels compacted into a gelatinous thickneſs. To this claſs belong the vaporous juices of the ventricles of the brain, of the pericardium, pleura, peritoneum,

vaginal

forming mucus. It is made up of a leſs proportion of water than the preceding genera, with a pituitous, tenacious principle ductile into threads, which when dried leaves much earth. This phlegm is wonderfully increaſed and diminiſhed, according to the diverſity of climate, atmoſphere, aliments, drink, and way of life; and it is thrown out of the body to the great ſafety of the conſtitution, and at the ſame time ſerves for lubricating the various internal places and canals. The moſt remarkable of this kind are, the mucus of the noſtrils, fauces, aſpera arteria, alimentary canal, gall-bladder, urinary paſſages, vagina, and in part the liquor of the proſtate gland. (4.) The oily and ſebaceous: a ſpecies differing from all, ſecreted on the external ſurface of the body, for lubricating the ſame, and defending it againſt friction and the injuries from the air, depoſited from the blood in real cryptæ, or ſecreted through orifices or canals proper to the places for which it is deſtined. With a very ſmall proportion of water it unites a great deal of oil and inflammable principle, ſome volatile acrid matter, with a little earth. The liquors of this kind, however, differ in ſome places, according as they are mixed with various foreign ſubſtances. The wax of the ears has an agreement with the bitterneſs of the bile; the odorous glands of the penis and nymphæ mingle in their compoſition more volatile acrid matter than the fat. The primary ſpecies of this kind are, the oily matter on the hairy ſcalp of the head and face, the inteſtinal liquid of Meibomius, the wax of the ears, the viſcid ſubſtance about the areolæ of the mammæ, about the umbilicus, the oily emanation under the axillæ, in the groin, in the interſtices of the fingers of the hands and toes of the feet, the odoriferous glands under the preputium, and in the nymphæ, and in general upon the whole ſkin. (5.) The gelatinous coagulable liquors, which I call *lymphatic* by a better appellation. This gelatinous part of the blood the ſmalleſt arteries depoſite into various, not all, the cellular places of the body: it is found particularly betwixt the tunic and parenchyma of the bowels, under the integuments of the body and its cavities, in the very cellular ſubſtance of ſeveral of the viſcera, and in the ſyſtem of the lymphatic veſſels.

The ſecond claſs comprehends ſuch liquors as are manifeſtly compoſed of a different mixture alone of the liquors of the firſt claſs, and when mixed have in part ſomething proper. The tears iſſue from a double fountain: the milk conſiſts of the very chyle of the food, of ſome ſaliva, oil, and fat, and a good part of the lymph: the compoſition of the bile is a great quantity of the ſalivary vaginal tunic of the teſticle, of the amnios[67], joints, and probably of the womb, with the juice of the ſtomach and inteſtines, of the renal capſules, and laſtly the lymph itſelf commonly known and called by that name.

CLXXXIX. The *ſecond* claſs is thoſe of juices; of which ſome are exhalable, like the former (CLXXX.), but being more ſimple and aqueous, are neither to be coagulated by fire nor by rectified ſpirits of wine; and others do not exhale, but, being depoſited in their reſpective excretory ducts, are expelled by ſome common outlet, proper to a part of ſome gland. To the former of this claſs belongs the perſpirable matter of Sanctorius, part of the tears and watery humours of the eyes. To the latter of this claſs belong the remaining part of the tears, the ſaliva and pancreatic juice, that of the renal capſules, and the urine. The ſweat ſeems to be a mixture of the perſpirable matter and the ſubcutaneous oil.

CXC. The *third* claſs, differing from both the preceding, includes the viſcid, ſluggiſh, or ropy juices; but ſuch as are of a watery diſpoſition, and not congealable into a jelly, but hardening into a cruſt-like or ſcaly ſubſtance, by exhaling their water. Theſe do

ſalivary liquid, a good deal of oil, a little mucus, and a ſingular balſamic bitter and ſtimulating ſubſtance: the liquor in the joints is manifeſtly mixed with oil, lymph, and ſome part of a ſaponaceous liquor: the liquor of the proſtate gland is mixed with chyle, mucus, and lymph. We have not yet a complete knowledge of the nature of the ſemen, at leaſt it is not to be referred to the mucus ſolely; although, that it contains mucus of a very mixed nature, is ſufficiently demonſtrated from its peculiar and ſpecific ſmell, its gravity, and the animalcula it contains.

My third claſs comprehends ſome hypotheſes, moſtly referring to fluid bodies, whoſe nature and diſpoſition ſtill is a myſtery to us. To this head I refer the electric matter of animals, magnetiſm, nervous principle.

[67] As we do no find that nature of all coagulable liquors conſtant, their paſſing to a thick gelly, but are often found like aqueous ones; ſo it by no means univerſally holds of the liquor amnii: for by my own experiments I am certain, that it often evaporates like water, without any appearance of gelly.

do not efferveſce with any ſalt, and are contracted and made thicker by acids. By lixivial ſalts they are diſſolved. By fire they are reſolved into water, a little volatile ſalt, and a little oil. Of this ſort is every kinds of *mucus* in the body, which we find ſpread through all the internal paſſages, whether deſtined for the tranſmiſſion of air, aliment, or urine, and the cavities above the parts of generation; to which ſort may be added alſo the ſemen.

CXCI. The *fourth* and laſt claſs is that of the inflammable juices, which at their firſt formation are indeed thin and watery, but, by time, ſtagnating and exhaling their more watery parts, become a thick, oily, inflammable liniment, often very bitter. To this claſs we refer the bile, ear-wax, ſebaceous and oily liniment of the ſkin, the marrow in the bones, and all the fat of whatever conſiſtence or in whatever part ſeated throughout the human body. To this claſs alſo belong caſtor and the yolk of an egg. And the milk itſelf, ſo far as it is butyraceous and inflammable, belongs to this claſs.

CXCII. Other humours, which we have deſcribed as ſimple, are compounded of the foregoing ones; as milk is compoſed of butter and water, and the liniment of the joints of lymph and fat.

CXCIII. Thoſe who conſider that in the blood are found a coagulating ſerum (CXXXVII.), an exhaling water (CXLII.), a ſort of viſcid mucus (CXXXVIII.), and laſtly an oil (CXLII.), may perceive the poſſibility to ſeparate from the blood all the foregoing claſſes (CLXXXVIII. to CXCI.) of humours; in as much as we thus ſee their conſtituent principles are already in the maſs of blood itſelf. But in what manner it is brought about, that oil is ſeparated from the blood in one part, a watery liquor in another, or a gummy mucus in a third, is a queſtion that ſtill remains to be explained, and requires a previous deſcription of the ſecretory organs themſelves.

CXCIV. The coagulable juices are ſeparated almoſt every where, from the arteries themſelves, into continuous excretory canals, without any intermediate organ or machine betwixt them. The proof of this we have from injections of fiſh-glue, water, and thin oils, which very readily paſs the red arteries, and are poured out like ſweat into all the cavities of the body, in which that coagulable vapour is naturally found; nor do the injections in this courſe meet with any intermediate knots or ſtops from any hollow cavities or cells. Finally, the blood itſelf, being ſo readily poured out into moſt of theſe cavities, without any permanent damage, when its courſe is either much obſtructed, retarded, or urged with a greater impetus through the arteries, ſhows plainly that there is a ſhort and open way betwixt the red blood-veſſels and thoſe excretory ducts.

CXCV. Another liquid, coagulable by acid ſpirits and alcohol, is the albuminous humour of the joints. This being compoſed of fat, medullary oil, and the exhaling liquor, conſtitutes an exceeding ſoft liniment, very fit for lubricating the cartilages, and leſſening the friction. For ſecreting this, there are appointed certain conglomerate glands of a peculiar ſtructure, which are ſituated in the articulations of the bones, ſo that they may be moderately compreſſed, but cannot be cruſhed.

CXCVI. The ſtructure of theſe glands is peculiar to themſelves. The larger cluſters of glandular kernels adhere, for the moſt part, to the bone, by a broad baſis wrapped up in fat. From thence, being drawn out into a kind of creſted edge, they pour out their liquor from an exceedingly thin border, by open ducts, which however I do not find very evident. Other leſſer ones, placed every where in the capſules of the tendons, and between the diverging fibres of the ligamentary capſules of the joints, ſeem to be much of the nature of ſimple glands, and are turgid with yellow mucous ſerum.

CXCVII. The uncoagulable juices (CLXXXIX.)

of the firſt ſort are ſecreted in the ſame manner with thoſe which harden (CLXXXVIII.); to wit, from the exhaling arteries, which ariſe from the red ſanguineous arteries, without any intermediate follicle or cavity betwixt them. Thus the veſſels, which pour out the perſpirable matter through the ſkin and lachrymal ducts of the firſt ſort, ſuffer a watery or thin gluey injection to tranſude ſo readily from the arteries, as leaves no room to doubt of this truth. And theſe ſecretory ducts have alſo a conſiderable degree of irritability; whence, by any ſtimulus or contact of acrid particles, they diſcharge more juice in a given time than what they diſtil in a ſtate of health.

CXCVIII. But in the latter ſalival kind of that claſs, the ſecretion is made by means of *conglomerate* glandules, which the ancients ſo called from their cluſter-like fabric, and eſteemed almoſt the only proper glands. Theſe are compoſed of roundiſh lobules or cluſters (ſomewhat like thoſe in bunches of grapes, currants, barberries, &c.) looſely conjoined together into larger maſſes by the yielding cellular ſubſtance, which, at laſt, often forms a denſer coat or covering to the whole, ſuch as we ſee in the parotid and maxillary glandules. Through the intervals betwixt theſe glandular cluſters or grape-like bunches, run the arteres and veins, which are here large or conſiderable enough. But moſt of the conglomerate glandules ſeparate their juices in ſuch a manner from the blood, and from thence diſcharge it ſo, that each kernel ſends out an excretory duct; which, joining with others of the ſame kind, form larger trunks, which at laſt, in the manner of a vein, end in one canal, which conveys the humour, ſeparated by the gland, to the part for which it is deſigned, as the cavity of the mouth, inteſtines, ſurface of the eyes, &c. There are, indeed, ſome of theſe glands in which the ſaid excretory ducts are either not preſent, or at leaſt not yet diſcovered; as we obſerve in the thyroideal glandules, thoſe called *capſulæ renales*, and the thymus; unleſs we ſuppoſe theſe to approach to the nature of conglobate glands[68].

CXCIX. The *acini* or kernels of theſe conglomerate glands are each of them circumſcribed and limited by a harder ſtratum of the cellular ſubſtance; by which ſubſtance they are alſo ſubdivided into leſs acinuli,

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[68] All phyſiologiſts and anatomiſts talk of the glands, as bodies which, by reaſon of a peculiar fabric ſuited to their functions, differ from the other parts of the body, as arteries, nerves, muſcles, bones, &c.; and for the greateſt part are endowed with the faculty of ſecreting. Under this name of gland come many bodies, though they are infinitely different: but you every where find the utmoſt confuſion, an illicit commixture of organs, which it is evident ſhould be ſeparated from each other; and ſo great an uncertainty in the deſcription of things, that unleſs you ſeparate the true from the falſe, the probable from the improbable, you ſcarcely know what really deſerves the name of gland. For nobody will be ſo ignorant of anatomy, who, if he conſiders all theſe things with a ſmall degree of attention, will not immediately ſee, that the name of glands is received in the moſt ample ſenſe. It is evident, that the mammæ, furniſhed with true glands, diſtinct papillæ, and real excretory ducts, in which they convey a certain liquid to the ſurface of the body, have little relation to the glandula thyroidea, deſtitute of papillæ, excretory duct, and liquor; nevertheleſs the name of gland has been conferred upon that ſame body equally as upon this laſt.

Indeed ſeveral authors of later times have agreed, that in glands there is a natural difference, as they ſay; ſo that they conſtitute one claſs of conglobate, and the other of conglomerate; to the former, referring thoſe bodies of glands in which no diſtinct papillæ appear; to the latter, thoſe which are furniſhed with real papillæ. But that diſtinction ſeems to me to come nearer nature, if the glands are ranked, according to the function of ſecreting, to conſtitute two claſſes; one of which comprehends the whole ſeries of glands, ſecreting a true and known liquor; the other contains the genera and ſpecies of the glands, whoſe liquor and mechaniſm of ſecretion is either not ſufficiently clear, or only fictitious.

Into the firſt claſs, therefore, deſerve to be placed all the true ſalival glands or other conglomerate ones; as the parotid, maxillary, lingual, lachrymal, thoſe of the cheek, mammary, the pancreas, Brunner's, and Peyer's ones of the inteſtines, Havers's ones of the joints, and an infinite number of cutaneous ones: For it is common to all theſe, the ſeries gradually diminiſhing, to be formed from leſs portions; the leaſt of which, marked by the name of *papillæ*, ſcarce acinuli, as is evident to the eye and by the microſcope. But it may be queſtioned, How does this ſubdiviſion end? Whether or no is every ſimple acinus or kernel hollow in its middle, that by receiving the humour tranſuding from the arteries into the follicle or cell, it may be ſent out thence by the excretory duct? Whether or no are we perſuaded to believe ſuch a fabric obtains from the ſmall ſhot-like ſtones and hydatides bred in theſe glands with the round ſcirrhi that ſometimes fill the kidneys? Whether are the larger viſcera, appointed for the ſecretion, of the nature of conglomerated glands? Whether is this opinion made probable from the morbid round concretions formed in the liver, ſpleen, kidneys, teſticles, and cortex of the brain; or from the bunch-like diviſion or appearance which thoſe viſcera have in younger animals? Whether the cellular ſubſtance, that ſurrounds the extreme vaſcules in all parts, does not communicate by open areolæ or cells, in which a ſecreted humour is poured by theſe glandules?

CC. In ſhort, none of theſe arguments appear true or concluſive. For the acini, which are found in the viſcera of brute animals, are component lobules, and not elementary parts; but are large and compounded for the conveniency of each beaſt. The morbid con-

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ſcarce viſible however, conſiſt of cellular ſubſtance, which comprehends arteries, veins, and an excretory duct, with an intermediate follicle or cavity. Theſe excretory ducts either open into a cavity with a ſmall mouth, as in the inteſtines or ſkin itſelf; or run into a greater duct, as they ſeek an iſſue in moſt of the ſalival ones, or ſeveral greater or leſs ones, as in the mammæ and ſublingual ones. By theſe marks, the true ſecreting glands, on the one part, may be diſtinguiſhed from the non-ſecreting; and on the other part, from the ſecreting viſcera, the liver, kidney, and teſticle.

The ſecond claſs comprehends a multiplicity of different parts, viz. the comprehenſive and ample ſeries of lymphatic glands; Pacchion's corpuſcles in the dura mater, not yet ſufficiently underſtood; the pinealis and pituitaria in the brain, unjuſtly called glands; the thyroid in the neck; the thymus in the breaſt; the capſulæ renales in the abdomen, &c. The proſtate, I think, as it gives out a true liquor, ſhould be ranked among the viſcera, rather than among the glands.

concretions are almoſt all of them a ſort of placentulæ, formed in the loculi of the cellular ſubſtance, and take up their ſeat even in the limbs themſelves, where there is not the leaſt room to ſuſpect any thing of a glandular fabric; and are compoſed, as to their matter, of oil, earth, and vaporous particles, extravaſated into ſome of the leaſt interſtices of the cellular ſubſtance, where, ſtagnating and compreſſing the adjacent follicles, they form to themſelves proper membranous tunics. On the contrary, the watery and fluid nature of the juice ſecreted in theſe glands (CLXXXIX.) is an argument that it meets with no arreſtment in the ſeparation, nor places of ſtagnation in its way. For all the juices that reſt any time in the warm cavities of the human body, which are full of abſorbing veſſels, are each of them more or leſs inſpiſſated, and approach either towards a mucous or an oily diſpoſition. Moreover, if there were any ſuch arreſtments, anatomical injections would meet with more difficulty in paſſing from the arteries into the excretory ducts of thoſe glands; which, under ſuch circumſtances, would be impervious to thick injections, and thin ones they would exhale into their cellular fabric. Yet we ſee that the ſuperlative art of great anatomiſts has not only conveyed injections, but even thick ones like wax, directly from the arteries of the ſalival glands, liver, &c. into their excretory ducts; and this without filling up any intermediate knot-like cavities, which, according to the foregoing hypotheſis (CXCIX.), ſhould be the caſe.

CCI. Therefore the *acini* or kernels of theſe glandules appear compoſed merely of arteries and veins divided and ſubdivided, parted and connected, by the intervention of a good deal of cellular ſubſtance, whoſe ſtrata growing gradually more compact or firm as they enlarge, at length ſhow their contents moulded into a ſort of globular nut-like figure. In the belief of this, we are confirmed by analogy in the lobes of the lungs, the lobules of the thymus, and from the ſtructure of inſects; but more eſpecially the fabric of the teſticle, in which we plainly ſee, that the lobules are formed of excretory ducts, connected together in faſciculi by a very ſoft membrane. But they ſeem not to pour their juices into a cellular fabric, which would intercept or make difficult the paſſage to an excretory duct. The late experiments alſo of very eminent anatomiſts have ſhown very ſmall, white, cylindric veſſels, to be the real elements of the viſcera; and it is to be hoped that this diſcovery will be confirmed by future obſervations.

CCII. Thin watery juices, neither coagulable nor wholly evaporating, are likewiſe in other parts generated without the aſſiſtance of conglomerate or kernel-like glandules. For thus the urine is depoſited from the red or ſanguinous arteries into membranous pipes, with which they are manifeſtly continuous, and form an eaſy way, admitting air, water, and mercury, to paſs in like manner. And after the ſame manner, though leſs evidently, the nervous juice ſeems to be ſeparated in the brain.

CCIII. The third claſs, or *mucous* juices (CXC.) are indeed almoſt every where ſeparated into, and diſcharged from, ſinuſes or hollow glands[69]. Theſe true glands or follicles have, in general, ſuch a fabric as makes up an ample cavity, every where circumſcribed by a membrane; but in ſuch a manner, that the fleſh itſelf of the part to which the gland adheres is often taken for another cloſe hemiſphere of the follicle. The ſaid cavity or follicle is generally round; but ſometimes it is oblong, and obliquely ly creeping betwixt the adjacent parts; as, for example, in the urethra of the male, and in the follicles of the ſinus muliebris. They are irritable; and when ſtimulated by acrid ſubſtances, increaſe the quantity of their ſecretions.

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[69] Many anatomiſts, and thoſe even of great note, often confound the words *glands* and *follicles;* ſo that ſpeaking of glands; they call them *follicles*, but when they talk of follicles, they call them *glands;* between which bodies, however, a great difference ſubſiſts. Folliculus and crypta is almoſt one and the ſame part, to wit, it denotes a membranous cavity, conſiſting of one or ſeveral places of retirement, into which the veſſels depoſite a liquor, remaining a longer or ſhorter ſpace in it, ready to be excreted for the moſt part by a mouth or even a canal. I would wiſh to uſe this word *follicle*, when we ſpeak of mucous liquors; and *cryptæ*, when we ſpeak of oily or ſebaceous liquors.

CCIV. Into theſe follicles or cells the leaſt arteries (or the vaſcular fleſh ſurrounding each crypta or cell, and completing its convexity) open by producted extremities within the cavity of each crypta, into which they diſtil or exhale their reſpective juice; where, being retained from the narrowneſs of the excretory duct, the more watery parts are drawn up by the abſorbing veins, which correſpond to and reſemble the exhaling arteries; and thus the follicular juices receive a conſiderable degree of thickneſs. The truth of this we are taught from the ſtructure of the ſimple follicles obſervable in the tongue, in which both the importing arterial ducts or pores, and likewiſe the excretory mouths, are viſible to the eye; and from the velvet-like tubuli lining the ſtomach of birds, in which a ſecretory villoſity manifeſtly hangs in the cavity; and laſtly, from injections which diſcharge a colourleſs wax into the ſimple glands[70].

CCV. Whether the mucous cavity of ſuch a glandule be long or round, it has always an excretory duct, which for the moſt part is none of the leaſt; altho', in the round mucous glandules, the diſcharging duct or orifice be leſs, in reſpect to the reſerving cavity, than in others. This diſcharging orifice often opens into the common large cavity, into which the mucus is to be poured, without any intermediate duct; for thus it is in the back of the tongue, and in the ſimple glands of the ſtomach and inteſtines, where they have been denominated *cryptæ* or cells by Ruyſch. The ſinuſes have often the like fabric opening without an intervening duct, as in the urethra of the male.

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[70] By metaſtaſis nature depoſites in diſeaſes a foreign matter in theſe follicles, as we ſee in the ſmall-pox found in the noſtrils, larynx, aſpera arteria, and inteſtines.

CCVI. Another kind of theſe glandules is, where ſimple follicles are folded up together in one common covering, and open with their gaping orifices into one common ſinus, without forming any true excretory duct. This fabric we obſerve in the tonſils.— Theſe are called *conglutinated* glands.

CCVII. Other ſimple glands of this claſs have an *excretory duct*, by which they expel their mucus; namely, a narrow, membranous, cylindric, ſmall veſſel, opening with its poſterior orifice into the cavity of the glandule, and with its anterior orifice opening into the common cavity, for which its mucus is deſigned. Theſe excretory ducts are of conſiderable length in the ſubcutaneous and ſebaceous glands, and in thoſe of the palate and wind-pipe. In ſome parts alſo, the pore or orifice, and its duct, are more eaſily demonſtrable than the follicle or body of the gland itſelf; as in the noſtrils, larynx, rectum, &c

CCVIII. In others, again, an aſſemblage of theſe ducts, ariſing each from its reſpective follicle, run together into one like the branches of a vein, ſo as to form a conſiderable excretory canal, common to a number of follicles. To this kind belong the compound mucous glands of the inteſtines, ſome of the larger in the cavity of the urethra, with the blind or impervious duct or ſinus at the root of the tongue; to which, in brutes and birds, add the fringe-like tubuli of the ſtomach. The glands of this ſort may be called *ſimple ones compounded or continuous:* but where they lie only contiguous one to another, they may be called *ſimple aggregate* or congregated glandules; as are thoſe of the fauces, ſtomach, inteſtines, &c.

CCIX. The inflammable juices (CXCVI.) are ſeparated by organs differing in their fabric. The fat and marrow are depoſited without the intervention of glands, from the ſmall mouths of the leaſt arteries into the cellular coat or rather ſubſtance; and the ſame fat again eſcapes from under the ſkin by ſmall pores or ducts, without the aſſiſtance of any glandular follicles. But the ear-wax, and the waxen or ſuety liniment of the ſkin, are ſeparated by glands of divers kinds. Moſt of the ſebaceous glandules are viſible enough, with an open or naked mouth in the ſkin, that leads immediately into the follicle, without any duct of conſiderable length; as we ſee in the external ears, noſe, rings about the nipples, in the female nymphæ, and the valley or groove that runs betwixt them and the external labia, in the clitoris, and in the male glans and prepuce. Theſe differ but little from the cryptæ (CCV.) except in their contained matter, which they ſeparate.

CCX. There are others of the ſebaceous glands, which have an excretory duct of a conſiderable length, like moſt of thoſe in the ſkin; which, being ſeated in the cellular ſubſtance, have conſequently a duct long enough to perforate the ſkin Thus we ſee it moſt evident in the face, where the length of the duct is often to be meaſured by the concreted maggot-like ſubſtance preſſed out; the bulk of which demonſtrates, that a follicle or cell lies under the narrower pore.

CCXI. There are ſtill other ſebaceous glands of the kind mentioned CCVIII. in which many cryptæ by ſmall ducts meet together in one larger excretory duct. Thus in the face, in ſeveral places, there are large pores in common to a number of ſubjacent cryptæ. And of this kind are thoſe ſebaceous ſinks or little inteſtines in the eye-lids: and thus it is in the ſecretory organs of the muſk-goat, beaver, hyæna, civet-cat, and muſk-rat, which gather their ſebaceous matter into one common receptacle.

CCXII. The milk, being a humour of its own particular kind, formed of oil and watery juices intermixed, is ſeparated by conglomerated glandules whoſe fabric we deſcribed at CXCVIII. Whether the ſecretion of the bile be glandular, is controverted; but there are many arguments to perſuade us, that the liver is a mere vaſcular fabric, whence the bile diſtils immediately from the extremities of the porta into the *pori biliarii*, or roots of the biliary ducts, without paſſing any cells or follicles by the way: and in this we are more eſpecially confirmed by the Ruyſchian art of injection, in which the wax paſſes directly from the porta into the biliary ducts, without exhibiting any intermediate knots or ſtoppages; and therefore we ſee the milk and bile are both of them much thinner and more watery than the fat, or the ſebaceous matter which thickens in follicles.

CCXIII. It now remains for us to inquire, how, from one common maſs of the blood, the ſame variety of peculiar juices are conſtantly ſeparated each in its reſpective place; ſo that we never ſee milk ſecreted in the kidneys, bile in the thymus, or mucus in the ſebaceous glandules. This problem will not be ſolved, till we ſhall have previouſly acquired a thorough knowledge of the intrinſic fabric that obtains in each ſecretory organ. In the mean time we ſhall here propoſe what has been hitherto advanced with certainty on the ſubject.

CCXIV. Now, firſt, the blood itſelf, from whence any liquid is to be ſecreted, in the various parts puts on ſuch a character or diſpoſition there peculiar to itſelf, that more particles of a like nature with the humour abound in that portion of the blood, which *nature* intends to ſeparate from it. In the liver, the venous blood arrives with a very ſlow motion, full of oil, and full of the ſemiputrid vapours of the inteſtines. To the teſticles, the blood is brought ſlowly through very long ſlender and inflected canals, ariſing at very ſmall angles, and paſſing out of the abdomen through a cold tract under the ſkin. In the carotids, it is probable that the ſtronger, ſpirituous, and denſe parts of the blood aſcend; while whatever is more watery deſcends into the abdomen and to the kidneys; alſo to the forming of the ſalival juice of the pancreas, and the liquor of the ſtomach and inteſtines.

CCXV. Another preparation of the blood, towards ſe-

ſecretion, is from its retardation in the leaſt veſſels: whereby the red and denſer parts go on by themſelves along the axis of the canal; while the other lighter and more ſluggiſh particles, going on with a leſs velocity, recede to the lateral openings or branches, ſo as to enter the ſecretory orifices, which paſs out from the ſides of the ſaid veſſels; and to theſe they adhere by their viſcoſity.

CCXVI. Theſe orifices, though of different diameters, are yet always ſmall enough, in their healthy and natural ſtate, to refuſe the red blood. Hence, therefore, we may conclude, that, being enlarged by an increaſed force of the heart, they every where admit a good deal of the red blood from the ſanguineous artery, which they ariſe from and open into, as we cannot with probability ſuppoſe them to be much leſs than the red globules: And hence the ſame ſecretory orifices or ducts, which refuſe thick injections of wax or ſuet, do nevertheleſs generally admit thinner liquors injected into the arteries. Therefore this is the firſt and moſt ſimple mechaniſm of ſecretion; viz. that the light or opening of the excretory duct may admit only ſuch particles as have their greateſt diameter leſs than the diameter of the ſaid opening. From this reaſon only it is, that the yellow arteries convey a pure liquor from the blood, and that the uriniferous ducts exclude both the red blood and coagulable ſerum. But this is not the ſole cauſe, ſince the ſame juices are generated by large as by ſmall animals.

CCXVII. Merely by this law, the ſecreted juices may be of many different ſorts: for thoſe whoſe lights or tranſverſe ſections are the leaſt will receive only the thinneſt juices, as in the ſmall veſſels of the brain; and the largeſt ducts will admit water and jelly, while the thickeſt fat will enter the biggeſt of all. Moreover, if a number of ſecretory organs are formed in a ſucceſſion from one ſecerning artery, each of them having large mouths or ducts; in that caſe, the laſt which come out from the ſaid artery will receive only the thinneſt juices. But if thoſe which are firſt formed in order from the ſecerning artery, have ſmaller ducts, then the laſt only will receive the groſſeſt juices. It may be objected, that though the veſſels in a fœtus are vaſtly leſs than in adult, yet the humours are the ſame. But thoſe humours which are called fat, bile, lymph, and urine in the fœtus, are vaſtly different from the fat, bile, lymph, and water, of a man.

CCXVIII. From hence only it is that the ſecretions are generally made immediately from ſanguineous arteries without paſſing the ſerous lateral ones, (XLV.) Theſe all ſeparate groſs juices; thick, coagulable, or watery; as the fat, urine, juice of the ſtomach and inteſtines, &c. But the ſecretions of the other thinner juices are made not from ſanguineous, but from ſmaller pellucid arteries ariſing from the former; to the ſecerning mouths of which, not only no red blood, but no ſerum, fat, or other groſs juices, can have admittance. Thus the more thin and pure humours muſt neceſſarily be ſeparated; as for example, in the eye.

CCXIX. Perhaps *the angle*, which the ſecretory branch intercepts with its trunk, contributes ſomething to ſecretion. For it is eaſily demonſtrated, that at right and retrograde angles, only the viſcid and ſluggiſh juices are expelled by the ſtronger force of the particles keeping the middle of the canal; but the liquids which are about to go off at half right angles, are thoſe which preſerve their velocity. For, in living animals, the velocity of the blood is greateſt in veſſels of the acuteſt angles, and leſs in thoſe of right angles, as men of veracity have obſerved. That the effect of theſe angles in the veſſels is conſiderable, with regard to the ſecretion, we are perſuaded from the ſtructure of the body itſelf; ſince they form different angles in different parts with reſpect to their trunks, and in ſome parts compoſe net-works. For the ſmalleſt veſſels, in general, reſemble the branchings of little trees or ſhrubs, the trunks and arms of them every way ſending out branches, but in different angles; ſmall in the large inteſtines, but larger in the ſmaller inteſtines. Thus, in the ſpleen, the ſmaller red arteries ariſe ſo thick from their trunks, that they reſemble a wiſp or ſprinkler; in the inteſtines, they reſemble pencil-bruſhes; ſerpents, in the kidneys; ſtars, in the liver; a radiated circle in the uvea; and in the teſticle a lock of hair curled up into a button. But we very properly preſume, that the Creator never made this diverſity of fabric for no purpoſe. We have not as yet, however, any account of theſe net-works that can be ſufficiently depended upon. Neither does there ſeem to be any affinity between the fabric of the veſſel and the nature of the liquor which it ſecretes: and, indeed, theſe net-works are almoſt ſimilar to the veins, as if made rather for ſhortening the paſſage of the blood in ſome meaſure, than for diverſifying the nature of the ſecretion.

CCXX. The *inflexions* of the ſmaller veſſels, as well arteries as excretory ducts, greatly retard the motion of the blood; in which, therefore, the greater part of the force received from the heart is evidently ſpent in changing the figure of the veſſels. The repeated inflexions, therefore, of the ſecretory arteries increaſe the viſcidity of the juice, by delaying the flux, and giving the parts more time to cohere or attract each other. But a ſtraight courſe of the veſſels increaſes the celerity of their fluid, whence a copious and eaſy ſecretion; but then it makes the ſecretion more impure, as we ſee in the urine.

CCXXI. That the ſmaller arteries have different *degrees of denſity* or firmneſs, there is no reaſon to doubt; ſince we actually find it ſo by experiments in the larger branches. But the denſer the capillary arteries, the more they reſiſt the light and ſlowly moving particles, and yield only to the more denſe ones that have a greater impetus. Irritability produces almoſt the ſame effects; for if the ſecretory ſtrainer has a very acute ſenſation, it will reject the groſs humours, and tranſmit the more fluid ones: inſtead of mucus in the urethra, it will ſeparate a thin yellow ſerum; and almoſt the ſame matter, inſtead of the ſebaceous matter that lies under the ſkin: the quantity of ſecreted liquor will alſo be increaſed; as for example, in the tears.

CCXXII. Again, the velocity is greatly increaſed, if the heart is near; if the artery is ſtraight, or if it is produced with a ſmall angle; alſo, when the excretory duct ariſes before the extremity of a larger arterial branch: and it is diminiſhed, when the ſmall ſecretory artery runs a long way capillary, whereby the blood loſes the greater part of its motion in friction. Finally, from whatever cauſe the diverſity may ariſe, a greater velocity increaſes the quantity of ſecreted liquor, and produces heavy, more groſs, impure liquids; it alſo gives a degree of fluidity to the ſecreted liquors, as it prevents the ſtagnation, by which they might contract a viſcoſity: but ſlowneſs increaſes the attraction and viſcidity, and renders the ſecreted juice more pure; as the ſimilar particles when brought together can better attract and join each other under a ſlow motion, ſo as to follow the courſe of the larger canal, while the thinner parts go off by the leſſer lateral branches. From hence it is, that, only the impulſe of the heart being too much increaſed, all the ſecretions are confuſed.

CCXXIII. Theſe conditions nature is able variouſly to join together or ſeparate, and impart to every ſtrainer in greater or leſſer degrees; and thus by various methods to modify the ſecreted humours. Anatomy furniſhes an example, if you compare the ſtrainer of the bile or ſemen, which are thick juices, with the ſtrainer of the urine and tears, which are fluid ones[71].

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[71] The difficulties attending the explication of animal ſecretion, no mortal, perhaps, will ever unravel: content we muſt be, if obſervation, in ſo manifold a confuſion of conjectures, ſhall impart a little light to the ſubject. Some phenomena undoubtedly are obſerved, which prove, that there is between certain bodies a certain mutual re-

CCXXIV. From all that has been hitherto advanced, we may now begin to perceive, that ſince the blood contains particles of various kinds; ſome ſluggiſh; others mucous; others coagulable, but fluid; ſome denſe and red; ſome watery and thin; others fat and groſs (CLXXXVIII. *et ſeq.*): among all theſe particles, thoſe which are the largeſt and moſt denſe, as the cruor, will go on moſt towards the axis of the veſſel, ſo as to paſs on in a continued courſe from the artery into the trunk of the ſanguineous vein (XXXIX.)

CCXXV. Thoſe particles which are groſs and ſluggiſh, as the fat, muſt needs go off laterally by larger orifices from the ſanguineous artery, by ſhort ducts; for long ducts would make a ſtop to ſuch a ſluggiſh juice as oil. The phenomena of the adipoſe ſecretion (XIX.) agree with this deſcription. Such parts as are coagulable, but ſpecifically heavier than thoſe which are merely watery, kept fluid only while the powers of life are in action; theſe paſs off laterally from the red arteries, into the arteries which are not red, but continuous to the red ones, and ſmaller; whether theſe pellucid ones are continued on in the nature of trunks, ſending off other ſmaller branches, like the leaſt arteries (XLI); or whether they exhale their contents by a ſhort extremity, like the veſſels of CLXX.

CCXXVI. Thin watery juices may evidently paſs off

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relation of uniting, and a power of converting, ſome particles, whoſe nature is very variable, into their own. The former ſhows attraction, the latter aſſimilation, but both as an effect. How many viſcera and other parts in the body, totally different in nature, if loſt, are formed and reſtored by the moſt ſimple aliment? What a variety of plants in one and the ſame native place grows and thrives with nouriſhment not at all different in quality? Upon conſidering the wonderful effects of putrefaction, contagions, and ulcers, who would doubt, that theſe changes are owing to the power of aſſimilation alone? Not, therefore, without great probability may we aſſert, that there is in the animal body a certain aſſimilating agent, which, in the ſecretory organs, gives the particles procured from the common ſtore-houſe of the blood, their own proper quality, though before of a far different nature.

off by any veſſels continuous with the ſanguineous ones, or the leſſer ones (XLIV.), provided they be only ſmall enough to refuſe the groſſer juices: and this, whether they come out from the ſides of the larger arteries; or whether by a long continued courſe, and ſending off all the groſſer juices by large lateral branches, they, at length, end in a ſmaller pellucid canal inſtead of a trunk; as for example, in the eye. To the production of theſe juices, the moſt ſimple fabric is ſufficient; even a direct continuation of the ſcretory artery itſelf into an excretory duct, as we ſee in the urine. Therefore, the ducts and veſſels have here a ſtraight and ſimple courſe, with few or no inflexions; and a proportionable velocity ſtill holds in the courſe of their contained juices. Such juices as, being watery, light, but viſcid at the ſame time, are conſequently ſluggiſh and leſs moveable; theſe may be eaſily ſecreted by ſhort narrow ducts of a leſs diameter than to admit the fat, and appended to the ſanguineous arteries: and, therefore, it is evident, theſe will be ſeparated from the blood more abundantly in ſome parts of the body than others; namely, where the velocity received from the heart's impulſe is leſs, the flexures of the artery more frequent, and where the extent of the capillary artery ſhall be carried to a greater length.

CCXXVII. Whether or no ought we to aſcribe to each particular part, the ferments, pores, ſpecific weights, or filters filled with their own peculiar humour, and admitting nothing that is analagous to it, which determine the nature of the humours to be generated? One who admits of theſe, ought to conſider the great difference there is in one and the ſame juice, ſeparated in the ſame part of the body, according to the difference of age, courſe of life, &c. The bile in a fœtus is generated ſweet; the ſemen thin, and without vermicles; the milk either none or watery; the urine watery, mucous, and inſipid; the uterine mucus very white; the cutaneous veſſels full of red juices;

the watery juices reddiſh; and the fat gelatinous. By the ſame organs, in an adult perſon, the bile ſeparated is ſharp or acrid; the ſemen thick; the milk butyraceous; the urine yellow, thin, and alkaleſcent; the womb diſcharges a menſtrual blood, and the aqueous humour is very clear. But, even in the adult perſon, how different is the urine? at one time watery; at another, thick or concocted; in a fever, heavier, full of ſalts and oils. The paſſions of the mind, which make no other change in the body than that of ſtrictures in the nerves, yet wonderfully change the ſecretions, and expel even the blood and bile through the veſſels of the ſkin. Add to this, the frequent diſturbance of the ſecretions, and the changes to which they are liable from ſlight cauſes; ſo that only an increaſed celerity ſhall cauſe ſeveral differing liquors to be ſecreted by one and the ſame organ: for blood has been known to paſs into almoſt all the paſſages of the ſecreted juices; into thoſe of the ſweat, tears, mucus of the noſtrils and of the womb; and into the lactiferous, ſeminal, and urinary ducts, as well as the fat. A true milk has been ſeen ſeparated by glands in the thigh. When the urine has not been excreted by its natural courſe through ſome defect of the kidneys, ureters, or bladder[72], it has paſſed by the ſkin, exhaled into the ventricles of the brain, or even into the whole cellular fabric. The perſpirable matter of Sanctorius, however thin, is often by cold driven to the kidneys; or, by fear, or medicines, determined to the excretory villi of the inteſtines. That exhaling viſcid juice is ſecreted by the ſame organ with the fat, from which it ſo much differs, into the celular ſubſtance, is re-abſorbed, and alternates again with the ſame, (XVIII. &c.) A ſalivation ſupplies the place of the Sanctorian or cutaneous exhalation externally, and of the cuticular exhalation internally. The bile, reabſorbed, evidently appears flowing in the veſſels of the eyes. Nor does there appear any thing in the fabric of any of the viſcera or glandules that can fix or maintain the nature of the ſecerned fluid. The ſpecific gravities of the viſcera and ſtrainers neither anſwer, according to the authors who treat of them, to the ſpecific gravity of the humours which they ſecrete; nor are they at all known by experiments that can be depended on.

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[72] A preternatural increaſe or hardneſs of the proſtate gland is here meant; which ſo compreſſes the neck of the urethra, as to prevent the tranſmiſſion of a ſingle drop of urine. I ſaw a caſe of this kind in a perſon of 70 years of age, who died of a ſuppreſſion of urine in the ſpace of ten days. Beſides the unuſual expanſion of the bladder, which contained ſix pounds of water, all the parts of the body emitted a urinous ſmell, the brain not excepted; in whoſe ventricles, as alſo in the pericardium, ſo great a fetor was perceptible to the byſtanders, that they compared it to that of a chamberpot. Another memorable example of the urine determined to other places, when its excretion is impeded, occurred in the winter of 1778. I diſſected a ſubject, who wanted moſt evidently one kidney, and veſſels, and ureter; the other was of a little ſize, and the bladder ſmall. All who knew her fled from her as from a ſerpent; even her own huſband left her; becauſe on account of the intolerable urinous ſtench they could not endure her company.

CCXXVIII. It now remains for us to diſcover, how the ſecretions, in a healthy perſon, become pure or uniform. For all the juices that have been lately ſecreted (without excepting any, even the oil or fat itſelf) have a great many watery particles intermixed; ſo that none of the thicker juices ſeem capable of being formed without having a mixture of the thiner watery ones: how then do the ſemen, bile, fat, mucus, and other thick juices, deprived of their ſuperabundant water, acquire their viſcidity and other qualities?

CCXXIX. For this end, nature has framed glands, with large and ſmall follicles or reſervoirs, for retaining the ſecerned juices, from which the watery parts are required to be ſeparated, to render the remaining part more ſtrong and viſcid. The mucus, at its firſt depoſition, is thin and watery, little differing from the perſpirable vapours or tears; in which ſtate it diſtils into the cavity of the noſtrils, wind-pipe, and in-

inteſtines. This is not continually diſcharging, becauſe the excretory orifice is narrow (CXCVI.); and the excretory duct being ſometimes long and ſlender, at other times repeatedly bent and winding, or tranſmitted through a hard cellular texture, or cloſed by ſome force equivalent to a ſphincter, ſo retards the juice, that it cannot paſs out without preſſure; or perhaps, not without being irritated by the quantity or acrimony of the juice, the follicle preſſes out the liquor, which incommodes it, by a kind of periſtaltic motion. This appears from the morning diſcharges of mucus by blowing the noſe, coughing up from the lungs, and by ſneezing after the nocturnal ſtagnation. In the mean time, the veins, extended into the cavity of the follicle, and ſpreading in every direction, abſorb the more aqueous parts from the thin mucus, that it may become thicker the longer it is retained; but if, by the force of ſome ſtimulus, it be directly diſcharged after it is ſecreted, it comes out thin and watery. Examples of this we have in the urethra, in the noſtrils, and in the ear-wax; as alſo in the bile, which, at its firſt ſeparation in the liver, is watery, and has but little yellowneſs or bitterneſs. It is, therefore, retained by a large follicle or gall-bladder; and there digeſted or exalted by the vital heat, and its more thin or watery parts exhaled or abſorbed by the veins; whence the remainder becomes more thick, bitter, and oily. The ſame mechaniſm takes place in regard to the ſemen; which, being reſerved in the ſeminal veſicle, is there thickened, ſo as to be very viſcid after long chaſtity; but in repeated venery it is expelled very fluid. In ſome places nature has made theſe receptacles two or three times folded together in one and the ſame organ, when her deſign was to form a very thick juice. Thus the ſeminal paſſage is in the teſticles reticular; in the end of the epididymis, one large canal ending in a larger veſicle: the veſſels of the teſticle are narrow, and ſo are the vas deferens and proſtatic duct. Hence there are nowhere

where real glandules, except for ſecreting a viſcid liquor. And if a viſcid liquor has been ſeparated from the arteries without a follicle, it always ſtagnates in a large follicle. The ſemen, bile, liquor of the joints and fat, afford examples of this.

CCXXX. A ſecerned juice may be likewiſe changed in its receptacle by the affuſion of ſome new liquor. Thus the ſemen thickens by an affuſion of the proſtatic liquor; the chyle is thinned by mixture with the ſaliva and pancreatic juice, and that which diſtils from the villi of the ſtomach and inteſtines, and by an affuſion of the bile it becomes alkaleſcent; and again the ſynovia or albumen of the joints is tempered by the two kinds of fat (CXCV.)

CCXXXI. Laſtly, whatever is abſorbed, can be of uſe to the animal according to its nature, after it is taken into the blood; as the ſemen gives a ſurpriſing ſtrength to male animals. For the moſt part, likewiſe, when a humour is long retained, a lixivial acrimony is generated, not without its own uſe, in the bile and ſemen.

CCXXXII. But the great uſe of the follicles and receptacles of glands is to preſerve the juice, of whatever kind it be, for thoſe times, in which it is moſt neceſſary to be employed in the actions of life. Thus the bile is reſerved for the time of digeſtion, the ſemen for due venery, and the mucus of the noſe is accumulated in the night to temperate the irritation of the refluent air in the day.

CCXXXIII. Therefore, as nature has in this way framed machines, by which the juices are retarded in the large and ſmall follicles; ſo ſhe has made others to expel them at ſuch convenient times. To ſome glands ſhe has given particular muſcles for this uſe; as in the teſticles of brutes, the urinary bladder, and the gall-bladder: or elſe ſhe has placed other muſcular machines round them, which, by acting at convenient times, expel their continued fluids; as, for example, in the muſcular coat of the ſtomach and inteſtines.

In other parts ſhe has added contiguous and incumbent muſcles to promote the diſcharge, as in the biventers and maſſeters of the lower jaw: or elſe ſhe has again joined to them a nervous irritability, which, being excited to action by any ſtimulus, opens the ſhut paſſages to the milk, ſeed, tears, &c.; or being touched by ſomething acrid, as already mentioned, diſtils the liquor more quickly; as happens to the bile, liquor of the ſtomach and inteſtines, and to the ſebaceous matter.

CHAP. IX.

Of RESPIRATION.

CCXXXIV. THE lungs completely fill the ſacks formed by the pleura; (LXXVII, LXXVIII.) We give this name to the two viſcera, which are diſtinguiſhed into right and left, having a broad baſis below, and terminated above at the firſt rib by an obtuſe point or cone. Anteriorly they are flat, externally convex, poſteriorly round, and in the middle concave to receive the heart. The right lung is larger than the left; and more frequently divided into three diſtinct lobes; the left lung more rarely. They are freely ſuſpended by the great blood-veſſels; unleſs you call that a ligament, which is made by the external membrane of the pleura, going to the lungs and to the baſis of the diaphragm. Betwixt the lungs and pleura is found a watery or rather ſerous vapour, of a coagulable nature, like that of the pericardium (LXXXII.); which vapour tranſudes from the ſurface of the lungs, continually in the fœtus, and not unfrequently in the adult. This is ſometimes increaſed, ſo as to form a dropſy, or thickens to a kind of ſebaceous matter; or laſtly, concreting into fibres, joins the lungs to the pleura [73].

CCXXXV. The external membrane of the lungs is ſimple, and thinner than the pleura, although continuous to it. It is ſpread all over them, from the adheſion of the great blood-veſſels of the heart; yet ſo as to be capable of retaining wind eaſily, without breaking, after being ſeparated from the lungs. The ſame membrane covers the interſtice or mediaſtinum of the lungs, like a bridge. It is joined to the lungs by a cellular texture.

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[73] Many examples occur in ſubjects who have died of inflammatory diſeaſes; as, after a pleuriſy, the whole lungs have been found covered with a purulent and almoſt ſebaceous membrane: the ſame

CCXXXVI. The ſtructure of the lungs is a heap of lobes ſeparated from each other by intermediate intervals, in which is extended a looſe cellular ſubſtance. Their firſt diviſion is into two, which are larger; and a middle one, which is leſs; yet cohering, then they are again ſudivided internally, through a long ſeries, into leſſer lobules down to the leaſt, till at laſt the ſmall lobules terminate in very ſmall membranous cells; which in adults, are variouſly figured, and full of air, and communicate on all ſides with one another. Theſe veſicles of the lungs, therefore, do not receive the air by a ſingle orifice from the wind-pipe, as a vial; but the air, exhaling from the leaſt branches of the ſaid wind-artery, is admitted in ſuch a manner into their irregular ſpaces, that it freely ſpreads through them from any one part of the lungs into all the reſt, and returns again in like manner. This is demonſtrated by inflation, which drives the air even through the leaſt branches of the wind-pipe into the ſmalleſt lobes; from whence it readily paſſes into all the reſt. Nor, in man and ſmaller animals, is the cellular fabric of the intervals ſhut up from the veſicles of the lungs, nor are the lobes ſurrounded by any peculiar membrane; for in the largeſt, as between the air-veſicles and thoſe cellular ſpaces ſurrounded with lobules, there is no commerce.

ſame thing may be ſaid of the kidney in an hepatitis, and of the whole alimentary canal in caſes of enteritis. I remember two very ſingular caſes. In a child of four years, labouring under ſcrophulous complaints, winter 1778, a thick membrane, difficultly ſeparable, covered the lungs; and in the year 1769, I deſcribed a ſimilar covering between the pia and dura meninges.

CCXXXVII. The air is driven into theſe veſicles thro' the wind-pipe, which ariſes from the larynx (hereafter to be deſcribed), and from that only receives its air. The firſt part of this wind-pipe is ſingle, and deſcends along the ſmooth bodies of the vertebræ of the neck, partly fleſhy and partly cartilaginous; namely, within the cellular ſubſtance that ſurrounds the wind-pipe, is formed a canal made up by a ſucceſſion of cartilaginous and muſcular rings. Theſe are thin and elaſtic; flatter and thicker in their foremoſt part, but thinner in their poſterior extremities, which are conjoined by ſtrong tranſverſe muſcular fibres; which adhering firmly to each extremity of the cartilage, complete the circle. The lowermoſt circles are leſs; the uppermoſt often augmented by an appendix; the next again perpendicular to the diviſion.

CCXXXVIII. The fleſhy rings, alternately placed with the cartilaginous ones, are made up of red muſcular fibres. Some of theſe are tranſverſe, connecting the detached ends of the annular cartilages; others deſcend from each upper to the next lower ring. But other muſcular fibres again, deſcending downwards from the cricoide cartilage, and having reached below the firſt diviſion of the bronchia, vaniſh within the lungs. The tranſverſe fibres contract or leſſen the diameter of the wind-pipe; the longitudinal ones render it ſhorter. Alſo within the lungs, betwixt the imperfect rings, is found a ſort of muſcular fabric, but leſs uniform.

CCXXXIX. In the cellular coat which ſurrounds the muſcular one, but eſpecially in the back part of it, along the poſterior interval that is betwixt the cartilages, are placed numberleſs ſimple glands, which open by very ſmall ducts, like pores into the cavity of the wind-pipe: by which pores they depoſite a watery and pellucid mucus into that cavity; which mucus, being without the leaſt acrimony, not coagulable into a hard ſubſtance like the humour of the eye, is of the greateſt uſe in defending theſe moſt ſenſible membranes from being injured by an impure air, full of particles, which, by their mechanical figure or chemical acrimony, might be very troubleſome. Laſtly, the internal tube of the wind-pipe is completed or lined by a membrane, which is continuous with that of the mouth, ſmooth, ſoft, and very irritable. The ſame cellular texture ſurrounds it which anſwers to the muſcular coat.

CCXL. The veſſels of all this part of the wind-pipe come in the neck from thoſe of the lower thyreoids; in the thorax, from other ſmall branches of the ſubclavian trunks, the mammaries, and the *bronchials* properly ſo called. Its nerves are numerous from the recurrent and intercoſtal ones.

CCXLI. In the upper part of the thorax, the wind-pipe is received between the laminæ of the poſterior part of the mediaſtinum; and at the third vertebra, or a little above, is divided into two branches reſembling the trunk itſelf, formed like imperfect cartilages, alſo furniſhed with ſimilar glandules; each of which branches enters the lung to which it correſponds, only the right is ſomething ſhorter and larger than the left. Having entered the lungs, the cartilaginous rings change into fragments, which become more and more difform, gnomonic, angular, triangular, and intermixed with a larger portion of the membrane, till at length, the cartilage decreaſing, the laſt branches of the bronchia become merely membranous.

CCXLII. Its laſt branches are inviſible, which exhale the air into the cellular ſpaces of adult lungs, and likewiſe receive the watery vapours exhaling from the arteries into the ſaid ſpaces; from whence they are thrown out by exſpiration.

CCXLIII. The blood-veſſels of the bronchia are the *arteriæ & venæ bronchiales*. The former are almoſt conſtantly two; one coming from the upper intercoſtal of the aorta, which is diſtributed either to the right only, or to both the lungs; the other, from the trunk of the aorta itſelf, going to the left lung. Sometimes there are more than two bronchial arteries to be ſeen; as, when there are three, by the addition of a ſecond from the aorta. But ſometimes again there is only one artery in common. The thoracic part of the bronchia ſituated without the lungs, has its proper veſſels from the aorta, the ſubclavian, mammary, or intercoſtal. The bronchial veins are moſt commonly two; the right from the vena azygos, the left from a peculiar branch of the ſubclavian vein and the left ſuperior intercoſtal. Theſe blood-veſſels travel together with the branches of the wind-pipe; and deſcend into their membranes in ſuch a manner, that the pulmonary arteries, in their way, inoſculate with their contiguous arteries, as the veins likewiſe communicate with each other. There are ſome inſtances where the pulmonary vein itſelf has given ſmall branches to the lungs, to the wind-pipe, and to the ſurface of the lungs.

CCXLIV. But there are other larger veſſels belonging to the lungs, called the *pulmonary artery* (deſcribed CVI. CVIII.), and the pulmonary vein (CX.) The great artery, in the fœtus larger than the aorta, and in the adult but little leſs, has two branches; the right larger but ſhort, the left narrower and longer. In the fœtus, the trunk itſelf is continued into the deſcending aorta, and is known by the name of *ductus arterioſus*. In an adult, that trunk degenerates into a ſolid ligament. The four pulmonary veins accompany the arterial branches and the aſpera arteria of the windpipe in their courſe through the lungs, ſurrounded with a good deal of cellular ſubſtance; which ſubſtance, being increaſed, at laſt compoſes the lungs themſelves. Within this cellular fabric, and likewiſe upon the ultimate ſpaces or cells, the air-veſſels and blood-veſſels are ſubdivided, ſpread, and interwoven like a net; and here the ſmall arteries exhale a plentiful vapour into their cells, and the veins abſorb a watery vapour from the ſame cells. Hence water tinctured, the whey of milk, or a thin waxen injection, being urged into the pulmonary artery, flows with a froth into the windpipe; or, on the contrary, being urged from the windpipe into the lungs, they penetrate into the pulmonary artery. In like manner, injections paſs from the pulmonary vein to the windpipe; or from thence again they may be forced into the veins. Laſtly, a liquor injected by the arteries, readily enters the pulmonary veins; and the reverſe.

CCXLV. The lymphatic veſſels, as in other parts, form a net-work upon the ſurface of the lungs, from whence there are branches conveying the lymph to the cavity at the back part of the mediaſtinum, and to the ſmall glands which lie behind the œſophagus, opening at laſt into the thoracic duct. The anterior pulmonary [74] nerves are ſmall, but the poſterior ones

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[74] I do not comprehend in what poſſible ſenſe the lungs can be ſaid to have neither many nor conſiderable nerves: For if I conſider the number and magnitude of the bronchial nerves, I would be inclined to ſuppoſe, that the lungs, of all the human viſcera, the organs of ſenſe excepted, receive, upon compariſon, many nerves, and therefore poſſeſs ſenſibilty. From many obſervations, I have found, that the primary fountain of the pulmonary nerves is the eighth pair, which generates the leſs anterior pulmonary plexus, conſiſting for ordinary of three branches; and the greater poſterior pulmonary plexus, formed of three or four larger branches, and two, three, and even four, leſs filaments: ſeveral branches are added to theſe from the recurrent and cardiac nerves; and ſometimes ſome filaments on the right ſide from the phrenic nerve, which intermix with the anterior plexus. But we ſhall only deſcribe the elegant fabric of the anterior plexus, being leſs known, as we have obſerved it in the right ſide in ſeveral ſubjects. A remarkable branch deſcends from the eighth pair behind the egreſs of the recurrent forewards, between the arteria anonyma, or common trunk of the ſubclavian and right carotid. Here a few branches being given to the coats of the artery, it ſeparates into two; one of which makes the cardiac; the other reaches the bronchia, and with it deſcends to the lungs, and ſends ſome branches more outwardly, which runs on with another larger branch from the trunk of the eighth, and compoſes an elegant ganglion, which might

ones ſomewhat larger: they come from a nerve of the eighth pair; and there are alſo ſome ſmall nerves to the lungs from the recurrent, and likewiſe from the cardiac plexus, which enter together with the large blood-veſſels. Hence the lungs have but little ſenſation; that of the little nerves, however, divided after the manner of the bronchia, is very acute. Nor are the lungs of an irritable nature.

CCXLVI. The quantity of blood which enters into the lungs is exceedingly great, equal to (or even perhaps greater than) that which is ſent in the ſame time throughout the reſt of the body; which, therefore, demonſtrates ſome very conſiderable uſe proper to this viſcus. And that this uſe depends manifeſtly upon the air, appears from the univerſal conſent of nature, in which we ſcarce find any animal without breathing; alſo from the ſtructure of the lungs in the fœtus, in which, for want of air, they are uſeleſs, receiving only a ſmall portion of the blood, which the pulmonary artery conducts from the heart. We come next, therefore, to ſpeak of reſpiration, by which the air is drawn into and expelled from the lungs.

CCXLVII. The element of air appears, from the principles of philoſophy, to be an elaſtic and ſonorous fluid, with a ſpring which cannot be deſtroyed. But the atmoſpherical air, which we commonly receive into the lungs, is impure, filled with a great quantity of watery and other vapours, alſo with ſalts and the univerſal acid, with the ſeeds of plants and animals, and other foreign matters; but in very minute particles, having a ſpecific gravity 859 times leſs than water, a cubic foot of air weighing between 610 and 694 grains. This air, which ſurrounds the earth on all ſides, being preſſed by the incumbent columns of its own maſs, perpendicularly, laterally, and in all directions,

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might be called *pulmonary*, ſituated behind the vena azygos, at its entrance into the cava. From this ganglion come out five or ſix branches, with blood-veſſels and branches of the bronchia, and are diſtributed through the lungs.

rections, enters wherever it meets a leſs reſiſtance, and with a conſiderable force, as appears from experiments made with empty or exhauſted veſſels, and by the air-pump; ſo that its preſſure on the human body is not leſs than 3000 pounds weight. It is repelled chiefly by the pores of the membranes, which yet are permeable by water: it likewiſe penetrates oil or mucus with difficulty.

CCXLVIII. This air is excluded from all parts of the human body by the ſurrounding cloſe ſkin, which, even when dried or tanned, is impervious to the air; but more ſo, as under the ſkin is placed the fat, making an equal reſiſtance to the narrow openings of the abſorbing veſſels. It, therefore, now remains for us to inquire, why the air enters the lungs of an adult perſon; for with this they are in a manner conſtantly full, and of courſe are equally preſſed, and reſiſting againſt the weight of the whole atmoſphere: but that the lungs always contain air, is evident; becauſe, however cloſe you compreſs them, they will be ſtill lighter than water; and even in the fœtus, after they have been inflated but a few times, they always ſwim; whereas they ſink to the bottom of water, if they have not given admittance to the air.

CCXLIX. The equilibrium of the air's preſſure being removed in any place, it conſtantly deſcends or flows that way where it is leaſt reſiſted (CCXLVII.) But air that is denſe and heavy will deſcend more eaſily than ſuch as is light, whoſe force ſcarce overcomes that of the air which is already in the lungs, nor is able by the ſame force to overcome the reſiſtance of the bronchia, and force by which the lungs compreſs the air contained in them. Hence an animal lives better in a denſe than in a light air: altho' that kind of air is always moſt tolerable, which is pure at the ſame time that it is light; ſuch as that of the higheſt mountains of the Alps. Therefore, for the air to enter the lungs, they muſt make a leſs reſiſtance to it than before; namely, the air, which is already in the cellular fabric of the lungs, muſt be rarified:

rified: but this effect will follow, if the cavity of the thorax, in which the lungs are contained, and which they exactly fill, be dilated. Thus the air, which is always in the lungs, expands into a larger ſpace; by which, being weakened in its ſpring, it makes a leſs reſiſtance to the external air; and conſequently a portion of the ſaid external air deſcends into the lungs, ſufficient to reſtore the confined and rarefied air, filling the lungs to the ſame denſity with that of the external air,

CCL. We muſt therefore deſcribe the powers which dilate the thorax to produce this effect. The breaſt or *thorax* is a ſort of cage made up of bones, muſcles, and cartilages; being almoſt of the ſhape of an oval tub, ſomewhat compreſſed before, but behind divided by an eminence, whoſe hoops are the ribs, which are of a remarkable ſtrength. In the lateral parts of this cage are placed the lungs; in the middle and lower part lie the pericardium and heart; after which it is taken up by ſome of the abdominal viſcera.

CCLI. The baſis of the thorax is formed by a column, a little crooked and gibbous on the upper and back part; and likewiſe, in that part of the baſis which is uppermoſt, the ſame is very much behind the others, into which twelve vertebræ coaleſce. They coaleſce, however, by the union of their bodies into a ſingle column, which is prominent in the forepart between the two cavities of the breaſt; divides the right from the left; and is plane in the forepart, and broad towards the ſides. A ſlight ſinuoſity receives the ribs in that place where the arch ſeparates from the body. They are bound together into one column, as well by the elaſtic plate interpoſed between every two bodies and coaleſcing with both, as by other ligaments and ſpines lying upon one another, and the joining of the ribs, by which means no motion can happen among them without the greateſt difficulty. The ſides of the breaſt are made up of twelve ribs. Theſe are in general bent in the form of an irregular arch, having a great curvature laterally and backwards, but extending in their forepart towards a right line. The bony parts of the ribs lie ſufficiently parallel with each other; the greateſt part of the rib is bony, round, and thick backward, but thin and flat forward. The other part forward is completed by a cartilage; which in general continues the figure of the rib, growing in a flat broad concavity of a nature different from the bony part, and which does not change into bone, unleſs in extreme old age.

CCLII. The poſterior and bony thick part of each rib terminates in a head; along from which, in the body of the uppermoſt and two lowermoſt ribs, runs a cavity or groove, formed in the other ribs, betwixt every two adjacent margins, which lie one towards the other. The vertebræ are tied to the ribs by ſtrong ligaments, of which the principal ſpread from each rib like rays into the next adjacent vertebra, other ligaments tie the tranſverſe proceſs to the tubercle of the rib, and others tie the ribs one to another and to the tranſverſe proceſſes at the ſame time. Moreover, betwixt the angle of incurvation and the juncture with the vertebra, each of the ten upper ribs ſend out a protuberance, which being articulated with the plain ſide of the tranſverſe proceſs of each vertebra, are ſo tied by ſhort and ſtrong ligaments to that proceſs, that the rib has liberty to make a ſmall aſcending and deſcending motion, but with a conſiderable degree of firmneſs.

CCLIII. Among theſe anterior cartilages, the ſeven uppermoſt reach to the ſternum, and enter into the lateral cavities which are incruſted with a cartilage in that bone, to which they are alſo made faſt by ſhort ligaments. Of the five remaining ribs, the uppermoſt is faſtened to the ſeventh preceding, and that to the next lower, by a ſtrong cellular texture, by which they form a continuous margin, which is at laſt alſo faſtened to the ſternum. The ſame are connected to one another both by proper ligaments, and cartilaginous appendices joined with them through the cellulоſity: the two lowermoſt are free, and connected only with the muſcles. Theſe inferior cartilages are united to one another and to the ſternum by ſtrong ligaments.

CCLIV. The firſt rib is the ſhorteſt, but more ſolid than any of the reſt. As they follow in ſucceſſion to the ſeventh and eighth, every two and two ſtretch themſelves into longer and more moveable circles. The eighth is the longeſt of all; and from thence, the lower down they are, they grow continually ſhorter.

CCLV. The direction of the upper rib is deſcending; but the ſecond rib joins the ſternum almoſt in a right angle, while the others aſcend both to the vertebræ and to the ſternum, but more to the latter. But the bony part of the ribs is placed in ſuch a direction, that the uppermoſt have their ſides in the forepart very much declined forward, almoſt tranſverſely. In the third ribs it is placed almoſt perpendicularly; in the middle ones, it projects a little outward in the lower part. Beſides, the ſtrength of the different ribs is very different. The uppermoſt, being ſhort, rather grow into the ſternum than form a joint with it; and being tranſverſe, and often as it were welded together, they make a very ſtrong reſiſtance. From thence the mobility increaſes downwards, till the loweſt rib, adhering only to muſcles, has the moſt eaſy motion.

CCLVI. The ſternum in general is a thin ſpungy bone, altogether one in adults, but is variouſly divided in the fœtus. Its upper and broader part reſembles an octagon; and is articulated with the clavicles, which are jointed very cloſely with the triangular head of the ſternum, and with the firſt rib on each ſide. The other part which is longer and narrower, grows broad downwards, and its ſides receive the ribs each into its proper angular cavities. The lower part, which is leſſer and ſhorter, imitates the obtuſe figure of a tongue. This is continued into a detached appendix, partly bony and partly cartilaginous, of a changeable figure, which they call the *enſiform* cartilage; and which is found of various ſhapes, ſometimes being obtuſe like a little tongue, ſometimes pointed like a ſword, ſometimes cleft, and ſometimes perforated.

CCLVII. In order, therefore, to dilate the ſeat of the lungs, and thus to put the body in ſuch a ſtate that the external air may ruſh into the lungs, it is neceſſary for the thorax to be elevated. By this means all the ſections of the thorax form right angles, and its capacity is increaſed. This motion is performed by various muſcles, which either operate conſtantly or only at certain times. The intercoſtal muſcles, therefore, all of them act perpetually in elevating the ribs. By this name we underſtand 22 muſcles; of which 11 are external, or next the ſkin; and as many internal, ſeparated from the pleura only by fat or cellular ſubſtance. The begining of the *outer intercoſtals* is at the poſterior articulation of the ribs (CCLII.); but the termination of them is in the anterior bony part of each rib, at ſome diſtance from the cartilage, in ſuch a manner, that the remaining ſpace betwixt the cartilage and ſternum to the muſcle is filled by a tendinous expanſion. The direction of theſe muſcles is ſuch, that the fibres deſcend obliquely forward, from the lower edge of the upper rib to the upper edge of the lower rib. And that their action is to elevate the ribs, all authors unanimouſly agree; becauſe they thus deſcend from the upper leſs moveable to the lower and more eaſily moveable rib, in ſuch a manner, that their lower point lies more diſtant or remote from the hypomochlion, or point of motion, which is in the coſtal articulation with the vertebræ, conſidering the rib as a lever.

CCLVIII. But the *internal intercoſtals* ariſe at ſome diſtance from the vertebræ, almoſt at the outer tubercles of the ribs beforementioned (CCLII.) From thence they proceed as far as the ſternum, into which the uppermoſt of theſe muſcles are inſerted above. The direction of theſe is contrary to that of the former, except the anterior part of the firſt or uppermoſt of them; ſo that they deſcend from the lower margin of the upper rib backward, to the upper edge of the lower rib forwards. Therefore ſome doubt of their action, becauſe their lower part is inſerted into that portion of the rib which is neareſt its articulation with the vertebræ, and which therefore ſeems to be the leaſt moveable: however, they elevate the ribs notwithſtanding this; for the great firmneſs or immobility of the upper rib, exceeding that of the lower, is evident from the articulation, weight, and ligaments there formed, which ſurpaſſes that mobility, ariſing from the greater diſtance of the centre of motion. This appears from the diſſection of living animals; in which we ſee the inner intercoſtal muſcles operate in the elevation of the ribs, and reſt in the depreſſion of them alſo from a flexible thread fixed to the rib of ſome human ſkeleton, and drawn in the ſame direction with that of the fibres of the inner intercoſtal muſcles; by which means the lower rib will be always approximated towards the upper. The greater firmneſs alſo of the upper ribs proves this, as they ſerve for a fixed point to the lower ones: for the firſt or uppermoſt ribs are from eight to twelve times firmer and leſs moveable than the lower true ribs; but the difference of diſtance in them from the centre of motion, is ſcarcely the twentieth part of the length of their whole lever. Laſtly, the elevating power of the internal intercoſtal muſcles appears plainly by experiment in a dead ſubject; when, by the thorax being raiſed, the muſcles inſtantly ſwell.

CCLIX. By the action, therefore, of theſe muſcles, the thorax is elevated, not altogether as one machine, nor would reſpiration be aſſiſted by ſuch a motion; but the ribs turning upon their articulations, though behind they are but little moved, yet the fore-part of their extremities deſcends, and forms larger angles both with the ſternum and vertebræ; but from thence in the middle of their arches, by aſcending, their lower edges are drawn upward. At the ſame time, the ſternum is thruſt out forward more from the vertebræ and from the ribs. Thus the ribs are both removed farther from the vertebræ, and the right ribs depart from the left; and the diameter on both ſides, betwixt the right and left ribs, betwixt the ſternum and the vertebræ, is increaſed almoſt to two lines: and therefore this enlargement, following in every imaginable ſection of the thorax, will ſufficiently dilate the cavity of the breaſt. This action of the ribs is more particularly complete in women, and in men who have no ſhortneſs of breath. Theſe effects are produced leaſt of all by the firſt ribs, but more by the following ones. In very ſtrong inſpiration, the ribs deſcend both behind and before; and, along with theſe, the ſternum and the ſpaces between the cartilage are leſſened. But this dilatation alone is not ſufficient for healthy breathing: nor is it ſo conſpicuous or evident in men; although, in them, the intercoſtal muſcles, by retaining and elevating the ribs, very much aſſiſt the inſpiration in a tacit manner, while they afford a fixed point to the diaphragm, that the whole force of that muſcle may be ſpent, not ſo much in depreſſing the ribs, as in urging down the abdomen. The greater part, therefore, of the ſpace which the thorax gains in inſpiration, ariſes from the action of the diaphragm.

CCLX. By *the diaphragm* we underſtand a muſcle expanded in a curvilineal plate; by which, in general, the pulmonary bags are ſeparated from the abdomen in ſuch a manner, that the middle and tendinous part of the ſeptum is nearly the higheſt, and ſupports the pericardium: its lateral parts, which ariſe from the ſolid parts of the thorax and loins, are every where lower; but the loweſt of all are thoſe which lie moſt backward. The fleſhy portions of this muſcle ariſe before from the inner or poſterior face of the enſiform cartilage, and from the ſeventh, eighth, ninth, tenth, eleventh, and apex of the twelfth, rib; after which follows an interval, in which the naked pleura lies contiguous to the peritonæum. From thence the muſcular appendices of the diaphragm, which are much the ſtrongeſt part of it, being collected on each ſide into two, three, or four round muſcular portions, ariſe fleſhy from the tranſverſe proceſs on each ſide of the firſt vertebra of the loins, and from the ſide of the body of the ſecond; tendinous from the middle of the body of the ſecond, third, and fourth, and with cartilages placed between them, always higher up in the left ſide, but lower down in the right[75].

CCLXI. All theſe fibres (CCLX.), becoming tendinous, form the centre of the diaphragm, which reſembles, in figure, an obtuſe index of a ſun-dial, having the middle of the larger angle ſupporting the pericardium, while the lateral angles or wings deſcend backward, the left being narrower than the right. This centre of the diaphragm is more moveable and at liberty than the reſt; except in the middle of its tendinous part near the fleſhy margin, where the incumbent heart makes a reſiſtance; but the lateral parts and the fleſhy portions belonging to them are the moſt moveable. The fibres of this tendon form a moſt beautiful web, principally indeed on the upper part; which ſtretches from the fleſhy part of each muſcle to the fleſhy part of the oppoſite one: thence remarkable inferior faſciculi are ſent off tranſverſely to the right and left, and alſo backwards, which laſt portion is the uppermoſt.

CCLXII. There are two holes in the diaphragm; of which that on the right ſide of its tendinous part is ſomewhat ſquare, and circumſcribed by four ſtrong tendinous portions; the left, which is elliptical, lies betwixt the right and left fleſhy portions, which ariſe from the middle of the bodies of the vertebræ of the loins: under this opening they decuſſate and croſs each other once or twice, but above they end in the tendon. This left opening is therefore drawn cloſe together in the contraction of the diaphragm, while it is probable that the other opening remains immoveable. The tendons are but little changed in the motion of the muſcles.

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[75] We muſt not omit, in talking of the riſe of the diaphragm, two tendinous arches on each ſide, made over the pſoas and quadratus, from which ſome ſlender muſcular fibres come out, and are interſperſed among the muſcles of the ſeptum tranſverſum, produced from the reſt of the ribs and part of the lumbar vertebræ.

CCLXIII. The ſtructure of the parts, and the diſſection of living animals, demonſtrate, that the fleſhy portions of the diaphragm, which on all ſides aſcend from the firm parts to the middle and more moveable, do, by their contraction, depreſs the ſame, and by that means draw downward the lateral bags of the thorax, which contain the lungs (LXXVII.); and, by this means, the perpendicular diameter of the thorax is conſiderably increaſed. The fleſhy parts are more depreſſed; the tendon leſs, both becauſe it is fixed to the pericardium, and becauſe its own ſubſtance does not contract. Even the œſophagus and vena cava are contracted, while the diaphragm exerts its action. So that the diaphragm almoſt alone performs the office of reſpiration in a healthy man who is at reſt; as alſo in that thorax whoſe ribs are fractured, or the ſternum burſt, or where the perſon will not make uſe of his ribs by reaſon of pain. The force of the diaphragm alſo, in dilating the breaſt, is greater, according to the calculations that have been made, than all the reſt of the powers which contribute to reſpiration. A ſtrong inſpiration is as yet confined; becauſe, during the greateſt exertion of the diaphragm, the lowermoſt ribs are brought inwards, and thus far the thorax is ſtraitened. Leſt this ſhould always happen, the intercoſtal muſcles interfere in ordinary inſpirations; in very great ones they are inferior to the diaphragm. The phrenic nerve, which is more eaſily irritated than in moſt other muſcles, forces the diaphragm to perform its office. The lungs themſelves are altogether paſſive or obedient to the action of the air, ribs, and diaphragm; to which they are preſſed into cloſe contact on all ſides, as through a large wound; and when the thorax is denudated by the knife, leaving its capacity entire, the lungs appear through the pellucid pleura and diaphragm.

CCLXIV. But in larger inſpirations, which receive a greater quantity of blood driven into the lungs, and when there is any obſtacle or difficulty oppoſed to the action of the lungs themſelves; in theſe caſes, ſeveral other powers conſpire to elevate the thorax: which powers are inſerted either into the thorax, clavicles, or ſcapulæ; ſuch as the ſcaleni muſcles, trapezii, cervicales deſcendentes, ſerrati ſuperiores, and pectorales; together with the ſmall elevators; of which a more ample deſcription may be had from profeſſed ſyſtems of anatomy.

CCLXV. We have now ſurveyed the powers which are able to increaſe the capacity of the thorax in all its three dimenſions (CCLXIII. and CCLIX.) By theſe the cavity of the breaſt is dilated, ſo that it compreſſes the lungs leſs than before: the lungs then ſtrive to diffuſe themſelves over that ſpace, ſeeing they are never deſtitute of air, which expands itſelf by its elaſticity as ſoon as the preſſure is taken off. Without that muſcular force the lungs have no proper power of their own by which they are capable of attracting air: and even when they are moſt full of air, by having the aſpera arteria cloſed, the animal vehemently attempts to inſpire, by the efforts of its intercoſtal muſcles and diaphragm. It therefore remains, that the air (CCXLVII.), which is a heavy fluid, and preſſed on all ſides by the incumbent columns of the atmoſphere, muſt now enter the thorax with the greater force the leſs air the lungs contain; or yet more powerfully, if they contain no air: but with no force at all, if the air admitted through a wound in the breaſt preſſes upon the ſurface of the lungs. In this action, therefore, which is called inſpiration, the bronchia are every way increaſed, both in length and diameter; becauſe all the diameters of the thorax are increaſed: but in this act, the inflated lungs always follow cloſely contiguous to the pleura without leaving any intermediate ſpace. At the ſame time, the pulmonary blood-veſſels, which are wrapped up, together with the bronchia, in a covering of the cellular ſubſtance, are likewiſe with them extended in length, and ſpread out from ſmaller into larger angles; by which means, the circulation through them is rendered eaſier. While this is performing, the veſicular ſubſtance, or fleſh of the lungs themſelves, filled with air, increaſes thoſe ſpaces through which the capillary blood-veſſels of the lungs advance; whereby the veſicular preſſure, upon each other, and upon thoſe veſſels adjacent, is leſſened: thus, therefore, the blood will flow with greater eaſe and celerity into and through the larger and ſmaller veſſels of the lungs. Hence a dying animal is revived by inflating its lungs, and facilitating the paſſage of the blood to the left ventricle of the heart; and thus people, ſeemingly dead by being kept a long time under water, are again recovered. But as for the preſſure of the air upon the blood in the lungs in this action, it is ſo inconſiderable as not to deſerve our notice, as being 300 times leſs than the force of the heart; nor can it ever urge the air into the blood, as it may be eaſily forced by art with a ſyringe.

CCLXVI. It is by ſome queſtioned, Whether there be not air betwixt the lungs and the thorax? and whether this air, being rarefied in inſpiration, is not afterwards condenſed, ſo as to compreſs the lungs, and cauſe exſpiration? And they again aſk, Whether this opinion be not confirmed by the inſtances of birds, in which we find this matter to be truly ſo [76]?

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[76] By Camper's very elegant diſcovery, it is certain, that air paſſes into almoſt all the long bones of birds flying much in the higher

But we ſee every thing concurs to confute this opinion: for, immediately behind the pleura, in living quadrupeds, as well as in dead human bodies, the lungs are viſible, without any intermediate ſpace bewixt them; but the pleura being perforated, the lungs are immediately, by the contiguous air that enters, preſſed together towards the vertebræ. In birds, indeed, the lungs, being pervious to the air, admit it into the cavity of the thorax through large holes in their ſubſtance. But in theſe there is a manifeſt ſpace betwixt the lungs and the pleura. Large wounds, admitting the air only into one cavity of the thorax, diminiſh the reſpiration; but ſuch wounds as let the air into both cavities, quite ſuffocate or ſuppreſs the reſpiration. The thorax being opened under water, ſends out no bubbles of air through the ſaid water[77]; but in birds it does, becauſe they have air in their thorax. The imaginable ſpace betwixt the lungs and the thorax is always filled up by a watery or ſerous vapour, or elſe by the ſame vapour condenſed into a watery lymph. If the lungs adhere, they injure the reſpiration but in a ſmall degree; which ought entirely to ceaſe, if it required an intermediate air betwixt the lungs and thorax

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higher regions, into the cavity of the ſternum, the vertebræ, cranium, inferior maxilla, both from the lungs and through the Euſtachian tube, and goes from one cavity into another: ſo it does not ſeem improbable, that the ſame may paſs out by the ſurface of the body. But in birds, who ſoar not ſo high, the air gains admiſſion through fewer bones. It is a pretty and ſufficiently agreeable experiment, to perforate the humerus or femur; and the air inflated into the aſpera arteria comes out at that foramen with the blood, which it has changed into froth; and *vice verſa*, the air inflated through the hole diſtends the lungs. In like manner, I have ſeen mercury injected into a foramen of this kind make its appearance in the lungs.

[77] Though it is my deſign, neither to renew this diſpute, nor to ſtart one of my own, it will not be, however, ſuperfluous to mention an experiment which I have often repeated on dead born infants: as oft as I have opened under water the thorax of ſuch children, not affected with any mark of putridity, I never obſerved any bubbles of air appear.

thorax. Finally, the external being admitted to any of the internal membranes of the human body, deſtroys their texture, if they are not defended by a plentiful mucus; of which we can find none upon the ſurface of the pleura.

CCLXVII. But reſpiration, whether by the admixture of a ſubputrid vapour, or by ſome other method, certainly vitiates the air, and renders it unfit either for inflating the lungs or ſupporting flame; and laſtly, it deprives that element of its elaſticity. We may ſuppoſe that this happens from putrefaction, ſeeing the air is rendered peſtilential by a crowd, and fevers of the moſt malignant kind are thus generated in a few hours. But in whatever manner this is produced, we are certain that the air is vitiated in the lungs; loſes its elaſticity; and thus cannot keep the lungs diſtended, ſo as to tranſmit an increaſed quantity of blood through the dilated pulmonary arteries into the veins. Nor can the will dilate the breaſt beyond certain bounds, or aſſiſt that paſſage of the blood in an unlimited manner. A ſtate of body therefore will take place, in which the blood cannot paſs through the lungs.

CCLXVIII. Thus is generated a new reſiſtance to the blood continually coming from the heart: and in long retentions of the breath, as in making violent efforts, the venous blood, eſpecially of the head, ſtagnates before the right ventricle of the heart being ſhut, becauſe it cannot evacuate itſelf into the lungs; and thus ſwells up the face with redneſs, ſometimes burſts the veins of the brain, neck, inteſtines, kidneys, and laſtly of the lungs, and right auricle of the heart. This occaſions prodigious anxiety and uneaſineſs to the ſpirits; this alſo is the cauſe of death in compreſſed air, in drowned people, and ſuch as are ſtrangled, which is much more ſudden than is commonly imagined. A living perſon therefore, that he may remove thoſe inconveniences which flow from an obſtruction of the paſſage of the blood, ſlackens the powers of inſpiration, and excites thoſe of exſpiration, which free the breaſt from an air too greatly rarefied.

CCLXIX. Theſe powers are, firſt, the elaſticity of the ribs, which being drawn upwards out of their natural ſituation, as ſoon as the powers which elevated them ceaſe to act, ſpontaneouſly place themſelves, ſo as to make more acute angles with the ſternum and vertebræ. To this end conduces likewiſe the elaſtic force of the bronchia and veſicles diſtended with air, which ſtrive to contract themſelves. Hence exſpiration is performed more eaſily and quickly than inſpiration; and hence it is the laſt action of dying people.

CCLXX. To this alſo contribute the oblique muſcles of the abdomen, together with the ſtraight and tranſverſe ones. The former of theſe are, in one part of them, faſtened to the lower ribs; and, in another part, they are attached to the os pubis and ilium, as a fixed point with reſpect to the breaſt. Therefore the ſtraight muſcles, being contracted, depreſs the arch or convexity, into which the abdominal viſcera are thruſt by the diaphragm, and bring the ſame nearer to a ſtraight line: at the ſame time the abdominal viſcera are preſſed by thoſe muſcles upward and backward againſt the diaphragm, which alone is able to give way; and yield up into the thorax, which at that time is rendered ſhorter. The oblique muſcles, for the ſame reaſons, compreſs the lateral parts of the abdomen, and urge the liver and ſtomach backwards, and preſs them towards that place where there is the leaſt reſiſtance. Laſtly, they draw down the ribs which were before elevated by the intercoſtals. The tranſverſe muſcles, indeed, do not draw the ribs; but they pull the cartilages of the falſe ribs a little inward, and render the whole capacity of the abdomen leſs, while at the ſame time they preſs the viſcera againſt the diaphragm. Along with theſe we may reckon the powers of the ſternocoſtal and long intercoſtal muſcles which are called *depreſſors*. By this joint force the ſuperior ribs deſcend; but the middle ones more, the uppermoſt leſs, the loweſt moſt of all; and the ſame are brought inwards by their margin: the cartilages aſcend, and return into acute angles with the ſternum; and the ſternum itſelf returns backwards with the ribs. By theſe means the thorax, contrary to its former ſtate (CCLIX.), is every where rendered narrower and ſhorter, ſo as to expel as much air out of the lungs as is ſufficient to relieve the uneaſineſs cauſed by its retention (CCLXVIII.)

CCLXXI. In more powerful reſpirations, when the inſpirations are made greater, the exſpirations are likewiſe increaſed by the aſſiſtance of ſome other powers, as of the ſacrolumbalis, longiſſimus and quadratus muſcles of the back and loins. This force, by which the air is blown out of the lungs, is ſufficient to carry a leaden bullet, weighing above a dram, to the diſtance of 363 feet; which force is equal to a third part of the preſſure of the atmoſphere. But, in a healthy perſon, the muſcles of the abdomen alone ſuffice to an eaſy exſpiration, in which the lungs are not ſo much emptied of air as they are by a violent efflation.

CCLXXII. The effects of exſpiration are, a compreſſure of the blood-veſſels in the lungs, a reduction of the bronchia into more acute angles, a preſſure of the reticular ſmall veſſels by the weight and contact of the adjacent larger veſſels, and an expulſion of the corrupted blood from the lungs; by which means part of the blood heſitating in the capillary arteres, is urged forward through the veins to the left ſide of the heart, while at the ſame time that part of the blood is reſiſted, which flows in by the artery from the right ventricle. Exſpiration, therefore, will ſtop the eaſy paſſage of the blood through the lungs; and when the whole thorax is compreſſed together, repels the venous blood into the veins of the head, and fills the brain and its ſinuſes.

CCLXXIII. In this manner a freſh neceſſity follows for repeating the reſpiration; becauſe the collapſed veſſels of the lungs reſiſt the blood repeatedly expelled from the right ventricle of the heart. And this makes another cauſe of death in thoſe animals which expire in veſſels exhauſted of air: for, in ſuch, the lungs having the air drawn out from them, appear denſe, ſolid, and heavier than water; whence they are rendered impervious to the blood. Of the ſame kind is the death of thoſe who are killed by lightning, and perhaps by the noxious vapours of caverns. Thus, therefore, by the power of a moſt wiſe fabricature, the organs of exſpiration are relaxed ſo ſoon as that uneaſineſs is perceived, which ariſes from the hindrance of the blood's courſe through the lungs; and hence the powers of inſpiration are excited into action, whereby the motion of the blood through the lungs is rendered free and quicker.

CCXXIV. It is by ſome queſtioned, whether or no there are not other cauſes of alternate reſpiration? whether or no we may hope for any diſcovery in this matter, by compreſſing the vena ſine pari, the phrenic nerve, or intercepting the blood ſent to the brain? But thoſe are repugnant to comparative anatomy; by which we always find the ſame alternation in the breathing of the animal, independent of any ſuch nerve or vein. Whether or no reſpiration is from the alternate contraction of the antagoniſt muſcles, among which thoſe of exſpiration relax the others of inſpiration, and the reverſe? But in this manner, all the muſcles of the human body are perpetually in an alternate motion.

CCLXXV. From what has been hitherto ſaid, it appears, that reſpiration is unavoidably and abſolutely neceſſary to life in a healthy adult perſon; becauſe, whether the lungs remain long in a ſtate either of exſpiration or inſpiration (CCLXXIII. CCLXXVIII.), we ſee death will be the conſequence. Therefore no animal that has lungs like ourſelves, after it has once breathed and received the air into the inmoſt parts of the lungs, and by that means brought a new and large quantity of blood to that viſcus, can ſubſiſt longer

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than a few minutes without the uſe and benefit of a free air; but it will either periſh, or at leaſt fall into ſuch a ſtate as differs from death only in its being recoverable again by certain powers or actions. In an animal lately born, this neceſſity for air does not take place ſo ſuddenly.

CCLXXVI. But the uſe of reſpiration is different from this neceſſity; which nature might have avoided, either by uſing no lungs at all, or elſe by diſpoſing them in a manner reſembling thoſe of the fœtus. This uſe, therefore, of reſpiration muſt be very conſiderable, ſince all animals are either made with lungs, or with gills as in fiſh, or elſe with a windpipe diſperſed through all parts of the body.

CCLXXVII. In order to diſcover this uſefulneſs of reſpiration, let us compare the blood of an adult perſon to that of a fœtus, and alſo with the ſame vital fluid in fiſh. It appears then in a fœtus, that the blood is deſtitute of its florid redneſs and ſolid denſity; and in the blood of fiſh, we obſerve there is no heat, the denſity inconſiderable, and but little craſſamentum contained in it; and, therefore, all theſe properties, we are, by the nature of things, perſuaded, the blood acquires in the lungs.

CCLXXVIII. It may be aſked therefore, Whether the blood does not acquire its heat principally in the lungs? But this does not ariſe from the alternate extenſion and contraction, relaxation and compreſſion, of the pulmonary veſſels (CCLXV. and CCLXXII.), by which the ſolid parts of the blood are perpetually rubbed and cloſely compreſſed? The lungs therefore will add to the office of the reſt of the arteries, becauſe in them the blood is alternately relaxed and compreſſed more than in any other part of the body. But even when the lungs are obſtructed, ulcerated, and almoſt deſtroyed, a morbid heat ſeizes upon the body: but in the lungs the cold air very nearly touches the blood.

CCLXXIX. The denſity of the blood is, indeed, again promoted in the lungs, partly by the copious diſcharge of the watery vapour which is there ſeparated, by which the reſt of the maſs becomes ſpecifically heavier. But the ſame effect ſeems to follow here, as in other arteries, namely, from the attrition and preſſure which the blood here ſuffers in being alternately retarded, accelerated, and figured in its courſe through the modulating tubes of the leaſt veſſels, which give a ſphericity and denſity to the particles; hence it becomes denſer, as having more of the weighty globules, and leſs of the lighter fluid. And, in this reſpect, the pulmonary vein, being ſmaller than its correſponding artery, is of no ſmall uſe towards increaſing the attraction of coheſion betwixt the parts of the globules, ſo as to compreſs and bring them cloſer to each other. Nevertheleſs, cold animals, which have very ſmall lungs, have denſe and coagulable blood; as alſo a chicken before it is hatched. The blood alſo has a ſhort paſſage through the lungs: the paſſage through the whole body is longer, and the artery weaker; the heart, by which the blood is driven forward, is alſo weaker.

CCLXXX. It is therefore queried by ſome, Whether the air itſelf is not received by the blood in the lungs, ſo as to excite neceſſary vibrations therein? Whether this does not appear from the reſiſtance of bodies to the heavy external air; and from the air found in the blood-veſſels, in the cellular ſubſtance, and in certain cavities of the human body; alſo from the cracking obſerved by an extenſion of the joints; to which add, the air manifeſtly extravaſated from the windpipes into the hearts of certain animals, as in the locuſt; from air coming out of the blood and humours of animals in Mr Boyle's vacuum; together with a neceſſity of a vital oſcillation in the blood itſelf; and, laſtly, the increaſed redneſs of the pulmonary blood?

CCLXXXI. But that no elaſtic air is here received into the blood, is demonſtrated from the impoſſibility of forcing air into blood, if it retains its elaſticity; from the inutility of its reception, if the ſpring of it ſhould be loſt in the blood; from the perfect immutability of the blood, by cold; from the minuteneſs of the inhaling veſſels, with the mucus that perpetually lines the ſides of the veſicles in the lungs: to which add the nature of the elaſtic air itſelf, which is very unapt to paſs through capillary veſſels; with a repulſion of it by water, that hinders it from paſſing through paper, linen cloth, or ſkins that are wetted by water. Again, the air being driven into the windpipe, never paſſes to the heart; or whenever it does, it is forced thither by ſome great or unnatural violence: but the permanent air in the veſſels and humours of the human body, from a ſtate of inelaſticity, may become elaſtic by putrefaction, froſt, or an external vacuum. But ſuch permanent unelaſtic air is incorporated with all liquors; and taken into our bodies with the aliments and with abſorbed vapours, mixing ſlowly and with ſome difficulty. But there never were any elaſtic bubbles of air obſerved in the blood of a living animal; and ſuch air being inflated into the blood-veſſels of any living animal, kills it certainly and ſpeedily. Nor is there any great certainty of the blood in the pulmonary veins being of a brighter red colour. Laſtly, though air indeed is abſorbed by moſt of our humours, yet that abſorption is performed ſlowly, and takes up the ſpace of ſeveral days after the former air has been exhauſted by the pump. It then likewiſe lays aſide its elaſtic nature; nor is there any reaſon produced, why the air ſhould either be more ſpeedily abſorbed by the blood, or why it ſhould retain its elaſticity after it is ſo abſorbed[78].

CCLXXXII.

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[78] In theſe our times, it is now too much a matter of diſpute, as if it were a ſubject entirely new, I mean the different kinds of air; to wit, fixed, inflammable, narcotic, nitrous, &c. which were partly known to Helmont, Newton, Boyle, Camerarius, Hales, and ſeveral others; but the pneumatic theories in general have been remarkably elucidated, increaſed, and limited, as occaſion required, by the laudable induſtry of Drs Brownrigg, Black, Cavendiſh, Prieſtley, Spielman, Erxleben, &c. If, in a few words, I might offer my opinion about the air found in our bodies, which has been the baſis of ſo many diſputes, I am perſuaded, that

CCLXXXII. Whether or not is the blood cooled in the lungs; and whether or not does this ſeem to be true from the death of animals, in air which is hot to ſuch a degree as equals the heat of the hotteſt breezes in the moſt ſultry dog-days? Whether the pulmonary veins are not, therefore, leſs than the arteries; and whether the deſire of cold in people that are working hard does not ariſe from thence? That the blood is cooled in the lungs is thus far true, as it warms the contiguous air, and therefore loſes ſomething of its own heat. But that this was not the principal deſign of nature, is evident; ſince no one will ſay that the venous blood is hotter than the arterial, although ſome pronounce the former to be ſomewhat cooler; but nobody ever obſerved the left ventricle of the heart cooler than the right. But the venous blood enters the lungs; if it be there cold, it will follow, that the arteries muſt receive it in ſtill a colder ſtate. But then here the degrees of heat which the blood communicated to the air are again recovered by it. And, indeed, a perſon may live in an air much hotter than the blood itſelf; of which we have a familiar example in baths and the warm countries. The pulmonary artery in a fœtus, which does not reſpire, is greater; and the larger area of the right auricle and ventricle of the heart, is likewiſe

that the atmoſpheric air is a very compound fluid, conſiſting of parts of a very different nature and quality; which parts, when mixed with any primigeneous fluid as a vehicle, make the common air we inhale in inſpiration. This primigeneous fluid is, perhaps, that air which we obſerve in animals, vegetables, and likewiſe in the earth itſelf, differing only according to the various ſubſtances with which it is united. If there is mixed in a due proportion with this univerſal fluid, any elaſtic, ethereal, electric principle, or any particles not yet fully underſtood, perhaps there will reſult ſalubrious atmoſpheric air. But it will become infected and noxious in various degrees, from an admixture of putrefactive ſubſtances, narcotic or inflammable ſuffocating elements. For that reaſon it ſeems to me very proper, that our judgment about the ſalutary or noxious quality of the air ſhould be directed by theſe principles; and hence it will be in our power to correct unwholeſome air, provided we know what qualities the air ſhould poſſeſs which is moſt properly ſuited to the function of reſpiration.

wiſe much greater in a fœtus; which ſeems neceſſary to reſerve and retard the blood, as the pulmonary vein being narrower accelerates it.

CCLXXXIII. Whether or not is the redneſs of the blood produced from the air? This is contradicted by what we ſee in cold animals, which, though they are almoſt entirely deprived of the uſe of air, have blood equally red with that of warm animals; from the certain connection of redneſs in the blood of frogs with their having plenty of food, and a paleneſs of it with a want of food; and from the air, as we have juſt now ſaid, being denied acceſs to the blood. Nevertheleſs, redneſs is produced when the air has acceſs to the blood, by which means it is alſo reſtored after it has been loſt; and, on the other hand, it is deſtroyed by the denial of the acceſs of air. Whether or not may not a more ſubtle element from the air penetrate the blood, and be the cauſe of its colour, as light is required for the colours of plants?

CCLXXXV. Whether the uſe of the lungs is to abſorb a nitre from the air to the blood? or whether the florid colour, obſervable in the ſurface of a cake of blood, be owing to the ſame cauſe, while the bottom part looks of a dark and blackiſh colour? and whether or not this is a prſervative againſt the putrefaction of the animal? remain as queſtions with ſome. That there is a kind of volatile acid in the air is certain, ſince that meeting with a ſuitable earth forms nitre; for a nitrous earth, being exhauſted of its ſalt, and expoſed again to the air, becomes re-impregnated with more nitre. But the ſame univerſal acid, we know by certain experiments, meeting with a different ſort of earth, forms a vitriolic ſalt, or alum, or elſe ſea-ſalt. For the caput mortuum of ſea-ſalt, which remains after the diſtillation of the ſpirit, recovers ſo much ſtrength from the air, as enables it to yield more ſpirit by diſtillation; even in ſnow there is a cubical ſalt: but marcaſite perſpires a true vitriol; and colcothar recovers again the acid ſpirit, which was drawn from it; alſo fixed alkali, expoſed to the air, turns into a vitriolated tartar. This, therefore, cannot be the uſe of reſpiration, becauſe thoſe ſalts abound in too ſmall a quantity in the air for ſuch uſes; and air is fitteſt for breathing when pure in high mountains, where thoſe ſalts are the leaſt to be found; nor is there any nitrous ſalt as yet known to be found in our blood.

CCLXXXVI. If it be aſked, Why tortoiſes, frogs, lizards, ſnails, ear-wigs, and other inſects, live long without air? we anſwer, That in them the lungs are given not ſo much for the preparation of the blood, which they receive but in a very ſmall quantity, as for the uſe of ſwimming in the water: and from hence it is that their lungs are immediately joined with the vena cava and aorta. But inſects, we know, draw the air in, and exhale it again, through points in the ſkin. If it be aſked, Why all animals periſh in air that is confined or not renewed, although the animal be ſmall, ſuch as little birds? we anſwer, Becauſe the air, which has once entered the lungs, and been fouled by watery vapours, is rendered leſs elaſtic, and unfit for reſpiration, by alkaline vapours: not becauſe it becomes lighter; for the mercury falls but little in air which has not been renewed, and which has killed an animal. Hence it is that the animal ſurvives longer in air that is more compreſſed than that of the atmoſphere: for in that caſe there is a greater proportion of the elaſtic element, which takes up a longer time to corrupt. But, even in other caſes, confined air is rendered deſtructive only by ſtagnation, and filling it with vapours. But the reaſon why animals ſwell in an exhauſted veſſel, is, from the extrication and expanſion of the unelaſtic air lodged in the blood and other juices.

CCLXXXVII. There is a certain conſent or proportion between the pulſe and reſpiration; ſo that, according to the common courſe of nature, there are three or four pulſes counted to one reſpiration. But if more blood is ſent to the heart in a given time, the numbers both of the pulſe and reſpiration are increaſed. This is the reaſon of the panting or ſhort breathing in a perſon that exerciſes his body with any conſiderable motion; whereby the venous blood is returned faſter to the heart (CXLII.) But if the blood meets with a greater reſiſtance in the lungs, ſo that it cannot paſs freely from the right into the left ventricle of the heart; then reſpiration is increaſed, both in number and magnitude, in order to forward its courſe: and this is the cauſe of ſighing, yawning, and wheezing; of which the firſt is a deep inſpiration; the ſecond ſlow, and very great; and the third, a frequent and imperfect one. The number of reſpirations, however, does not always increaſe with the pulſe; of which we have an example in thoſe fevers where the lungs are not affected.

CCLXXXVIII. The mucus, which lines the ſenſible membranes of the air-veſſels in the lungs, may become troubleſome both by its quantity and acrimony; it has been known to cauſe even ſuffocation in a dropſy of the lungs. Therefore its quantity, adheſion, or acrimony, excites a cough; namely, an irritation of the reſpirative ſyſtem, by alternate large inſpirations, ſucceeded by large and quick exſpirations, together with ſudden ſhocks of the abdominal muſcles; by which the mucus, and ſometimes calculous matters, are expelled from the lungs.

CCLXXXIX. Laughter differs from coughing in its cauſe, which reſides commonly in the mind, or at leaſt conſiſts in a certain titillation of ſome of the cutaneous nerves; and, moreover, becauſe it is made up of imperfect quick exſpirations through the contracted glottis, leſt the air ſhould be totally evacuated from the lungs. Hence laughter, in a moderate degree, conduces to health; becauſe, in the time of one full inſpiration, many ſhort inſpirations and exſpirations happen, and thus the concuſſion is greater. Hence its danger of ſtagnating the blood;

becauſe the exſpiration is not full or entire, whereby the blood is admitted into the pulmonary artery without being ſuffered to paſs through it. Weeping begins with a great inſpiration, after which follow ſhort alternate inſpirations and exſpirations; and the ſame is finiſhed with a deep exſpiration, that is immediately joined by a large inſpiration: hence it has nearly the ſame good and bad effects; and, when moderate, is conduces to relieve the anguiſh ariſing from grief. An hickup is a very great, ſonorous, and ſudden inſpiration[79]. Sneezing conſiſts of one large or deep inſpiration, which is followed immediately with a powerful and ſudden exſpiration; and the acrid matter is blown out by it in ſome quantity from the noſtrils.

CCXC. The ſecondary uſes of reſpiration are very many. It exhales, as an emunctory, parts redundant, or even noxious, from the blood, which would ſuffocate, if they remained in the air; and the breath of many people, ſhut up in a cloſs place, impregnates the air with a ſuffocating quality. On the other hand, it abſorbs from the air a thin vapour, of which the uſe is perhaps not ſufficiently known[80]. It is by this

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[79] In hickup, which always produces its effect by reſpiration, the œſophagus often ſuffers conſiderably; on which account much alleviation is to be hoped for, if we ſwallow any thing at different times.

[80] Among the uſes of reſpiration, ſeeing ſeveral of them are accounted of the ſame importance, may be counted the power of reſorption; by which the lungs abſorb by means of their veſſels, from the air inhaled in inſpiration, not only vapours mixed with the air, but mingle with our humours by means of the foramina, ducts, and proper canals, ſome other by far nobler parts, conſtituting at the ſame time one of the elements of the air.

This ſubſtance has got no proper name; nor do we know the nature of the part which is principally referred, in the firſt place, to the elements of the air, and, next, to our humours and blood. The once celebrated *pabulum vitæ* was an ingenious denomination, ſeeing, as has often happened, many perſons confined in narrow ſpaces, unleſs free acceſs of air is procured, have run the riſk of their life, from their wanting a proper renewal or pabulum this force that the abdomen and all its viſcera are continually compreſſed; by virtue of this, the ſtomach, inteſtines, gall-bladder, receptacle of the chyle, bladder of urine, inteſtinum rectum, and the womb itſelf, diſcharge their contents; by this action the aliments are principally ground or diſſolved, and the blood is urged

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lum, of air. But the name of *electric principle*, if we conſider the whole conſent of nature, ſeems more fitly adapted to the ſubject. For ſince the publication of the famous obſervations made by Gilbert, Guerick, Boyle, the Florentine academicians, Hawkſbee, Du Fay, Muſchenbroeck, Watſon, Ludolph, Winckler, Nollet, Franklin, Hartman, Prieſtley, and ſeveral others, both about the electricity of bodies in general, as well as of the atmoſphere in particular, the whole doctrine, by means of the new machine, the electrometer, from the expriments of Volta, Wilſon, Wilkenius, his ſerene highneſs Galitzin, Lightenberg, &c. has received ſo great additions, that it might almoſt be aſſerted, that the electric matter of the air is collected in the moſt ſimple manner by almoſt every body. From all thoſe experiments we collect,

1. That there is in the air a fluid which, in different ways, may be increaſed in one place, and diminiſhed in another; which, when collected *ſecundum artem*, exhibits electric ſparks; but, when collected in the clouds, breaks forth in lightning and thunder.

2. If from its too great congeſtion in any region of the atmoſphere or in the clouds, the circumambient air wants its due proportion, our reſpiration is leſs refreſhing, our ſtrength grows languid; but they are quickly renewed after a thunder-ſtorm, the equilibrum of the electric matter in the atmoſphere being effected, as it were, by the flaſhes of lightning.

3. Perhaps, too, we learn a method, and the remedies, by which we may artificially remove this defect; it is worth while at leaſt to conſider of this.

4. This electric matter paſſes into the blood or lymph by innumerable pores and foramina, with which the inſide of the larynx, aſpera arteria, and bronchia, abound. Upon the diverſity of theſe holes, both with reſpect to number, condition, and mucus, with which they may be covered, and to the ſize of the lungs, depends the reaſon why all men cannot inhale and abſorb the ſame quantity of electric matter from one and the ſame air.

5. It will not be eaſy for any perſon, in an affair deſtitute of ſufficient obſervation, to unravel what uſe this ſubſtance ſerves in animal bodies, and what functions depend upon it. Whether is the tone and irritability of the fibres of the body principally ſupported by it? Do the increaſe and cauſes of animal heat proceed from

urged through the ſluggiſh veſſels of the liver, ſpleen, and meſentery. It excites a kind of flux and reflux in the blood, ſo that it is alternately preſſed back towards the extremities of the veins, and a little after is propelled towards the heart by an accelerated velocity, as into an empty ſpace. Moreover, inſpiration ſerves to convey odours along with the air to the organs of ſmelling. By this, the air is mixed with the aliments; which it conduces very much to break and diſſolve towards a perfect digeſtion. But even ſucking, ſo neceſſary to the new-born infant, is made by the uſe of reſpiration, and forming a larger ſpace in the mouth, in which the air is rarefied; ſo that, by the greater preſſure of the outward air, the milk is driven into that part, where it is leſs reſiſted. Laſtly, the voice itſelf is owing to the air which we breathe; and, as it is one of the principal effects of reſpiration, we think it may be proper to give its deſcription here.

CHAP. X.

Of the VOICE *and* SPEECH.

CCXCI. THE *larynx* is the principal organ of the voice; for, that being injured, the air paſſes through the windpipe without yielding any ſound. By the larynx, we underſtand an aſſemblage of cartilages, joined into a hollow machine, which receives the air from the fauces, and tranſmits it into the windpipe, having its parts connected together by ligaments and muſcular fibres. Among theſe cartilages

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from it? I think it is clear, we ought hence to ſeek the cauſe of animal electricity; which is very conſpicuous in cats, and likewiſe horſes, and many men, by the numerous ſparks which may be made to appear iſſuing from their bodies. This is perhaps the cauſe of the greater danger to which ſome men are liable of being ſtruck with thunder. The ſpontaneous burning of ſome bodies in nature are undoubtedly to be aſcribed to the ſame cauſe; and the alacrity and vigour of ſome temperaments ſurely is wonderfully increaſed by the preſence of this fluid. May this ſubſtance be joined with the acidum pingue and inflammable principle? Compare note 78.

lages of the larger kind, thoſe called the *annular* and *ſcutiform* are, in adults, frequently changed into bone. The anterior and larger part of this larynx, which lies almoſt immediately next to the ſkin, is compoſed of two cartilages; one called *thyreoides*, the other *cricoides;* to which laſt, the lateral parts of the larynx are ſo joined, that the portions of the cricoide cartilage are always ſo much larger as they are higher ſeated. The back part of the larynx is firſt made up of the ſaid annular cartilage, and then the arytænoides connected by muſcles. The epiglottis is looſely connected above the larynx with the thyreoide cartilage, in ſuch a manner, that it may be able to riſe up and ſhut down. The blood-veſſels of this part are from the upper thyreoids; and the nerves, below, are numerous from the recurrents; as above, alſo, there are nerves coming from the eighth pair variouſly inoſculating; ſome alſo from the intercoſtal. The former of theſe nerves is remarkably famous for its ariſing in the thorax, and being afterwards inflected round the aorta and right ſubclavian; and for the origin which it gives to ſome of the nerves of the heart[81], as well as for the experiment by which a ligature upon the recurrent is found to deſtroy the voice.

CCXCII. All theſe cartilages are connected by various muſcles and ligaments, with a certain degree of firmneſs, to the adjacent parts; and yet ſo that the whole is eaſily moveable together, as are alſo its ſeveral parts upon each other. Particularly the *ſcutiform* cartilage, or the thyroidea anterior, is compoſed of two plates, which are almoſt quadrangular, and inclined to each other in an obtuſe angle, which is foremoſt. Upon theſe cartilaginous plates are ſometimes

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[81] Principally the great branch, immediately upon reflexion, aſcends behind the larynx, goes in particular to the left ſide; and having become the cardiac, deſcends towards the heart, lungs, and their veſſels. I have ſometimes obſerved two recurrent nerves in the right ſide, which on both ſides gave branches to the œſophagus, aſpera arteria, and larynx.

times found two apertures, one on each ſide for the blood-veſſels of the larynx; but they are not very often to be obſerved. The upper proceſſes of this cartilage, terminating without any protuberance, are inclined upward and backward, to their connection with the horns of the os hyoides, by ſtrong ligaments, ſometimes mixed with bone. The lower parts of theſe cartilages are ſhorter, and adapted almoſt with a flat ſurface to thoſe of the cricoide cartilage; to which they are connected with a very firm articulation, by a ſtrong and ſhort cellular ſubſtance, uniting them on each ſide. The middle parts before, being perforated with ſtrong ligaments, are connected by their inſertion to the middle of the annular cartilage; and likewiſe by other ligaments above, deſcending from the horn of the ſcutiform cartilage into the upper part of the annular cartilage.

CCXCIII. The cricoide cartilage is before thick, and ſtrong: it is increaſed backwards, in form of a ring unequally truncated or cut through; and, in its middle part, is divided into two cavities by a protuberant line. This is firmer than the reſt of the cartilages, and, in a manner, the foundation of them: from this there are longitudinal muſcular fibres and ligaments, which deſcend into the windpipe (CCXXVIII.) The pharynx likewiſe is connected to the ſurface of theſe cartilages by many muſcular plates, and receives the larynx as it were into its bag. From this a ſhort ligament comes on both ſides to the arytænoide cartilage.

CCXCIV. The two arytænoide cartilages are of a very complex figure, ſpontaneouſly dividing into two parts[82]. Of theſe the lower is larger; and is connected by a moveable juncture with the protuberant cricoide cartilage, by a baſis moderately hollow; and the ſame ſends a proceſs forwards, which ſeparates the glottis, and ſuſtains the inferior part of the ventricle of the larynx. They aſcend upwards, of a triangular figure, with the poſterior angle hollow, the anterior convex, divided by three furrows or ſulci, and extenuated upwards, till they are at laſt finiſhed or terminated by a pretty thick, oval, cartilaginous head fixed on them. The lower part of theſe cartilages is connected by numerous muſcular fibres, partly tranſverſe, and partly oblique; of which the different directions are viſible enough, but the ſeparation of them impracticable. Theſe are called arytænoide muſcles. In the upper part, the arytænoide cartilage departs from its companion or fellow cartilage, leaving a cleft perpendicularly betwixt them, which has been (not very properly) by ſome called the glottis.

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[82] The number of cartilages compoſing the larynx, if we ſtick to a more accurate anatomy, ſhould be changed. Five are commonly reckoned; thyroid, cricoid, two arytænoides, and epiglottis: But nine muſt be numbered. For any arytænoide, as Haller indeed has remarked, but did not chooſe to abandon the old

CCXCV. The arytænoide cartilage is connected with the thyroideal by tranſverſe ligaments, ſufficiently ſtrong and elaſtic, but covered with the common mucous membrane of the larynx, which ligaments are inſerted into the flat angle of the thyroide cartilage (CCXCII.) Theſe ligaments may be drawn out or ſtretched

old opinion, has a ſmall new one placed above it, larger in proportion in the larynx of ſome brutes, as the dog and horſe, which is in the ſame manner joined to the arytænoides with the aſſiſtance of a capſular ligament by means of a diſtinct articulation, as the arytænoides are connected with the cricoide. Santorinus has already named them the *ſixth* and *ſeventh*. Beſides, I obſerved a few years ago, two new cartilages, or bodies ſimilar to cartilages, which I thought ſhould be taken into the number of the parts of the larynx. Theſe cartilages lie between the epiglottis and arytænoide in any ſide, but nearer the arytænoides, above the upper ligament of the glottis. They form a round maſs, about the thickneſs of a crow quill, and three lines long. They are extremely well ſeen, if, when the cricoide cartilage is diſſected, the poſterior part of the larynx is expanded; for then they are eaſily diſtinguiſhed riſing through the internal tunic. I think they are tolerably expreſſed in an elegant table, belonging to the third ſet of demonſtrations, which I got from my celebrated friend and anatomiſt M. Camper.

ſtretched from each other, by removing the contact of their arytænoide cartilages, and may be again conjoined by placing the cartilages one to another: and this is the true glottis, which is continuous, but at a right angle with the above-mentioned cleft (CCXCIV.)

CCXCVI. From the ſame angle of the thyroide cartilage, under a notch, from a firm ligament, and an erect ſlender ſtalk, is extended an oval cartilage, in its forepart convex, behind concave, and raiſed up in ſuch a manner, by its elaſticity, as to project conſiderably behind the tongue; but is ſo flexible or inclinable downward, whenever the root of the tongue is preſſed backward, that, by its tranſverſe poſition, it ſhuts up all paſſage into the larynx, and defends it in ſuch a manner, that whatever is contained betwixt this part, called the *epiglottis*, and the arytænoide cartilages, paſſes over downward into the pharynx. The epiglottis is conjoined to the tongue by pale membranous fibres, and to the os hyoides it is connected by many membranous expanſions. But as for muſcular fibres from the thyreo-arytænoidal and arytænoidal muſcles, it has either none at all, or elſe ſuch as are too minute to have any effect upon its elaſticity.

CCXCVII. By the ſides of the ligaments of the glottis (CCXCV.), there are two other upper and ſofter ligaments, which go out parallel from the arytænoide cartilage to the ſcutiform one, which ligaments are ſomewhat leſs tendinous and leſs elaſtic. Betwixt theſe two ligaments, on each ſide (CCXCV.), a peculiar cavity or ventricle deſcends, having the figure of a compreſſed parabolic ſinus extended downward betwixt the double membrane of the larynx, opening conſtantly with an elliptical mouth by the ſide of the glottis in the larynx[83].

CCXCVIII. Laſtly, all the internal cavity of the larynx is lined with the ſame ſoft, ſenſible, or irritable and mucous membrane, as we before deſcribed in the windpipe (CCXXXIX.) But this membrane is watered by a great number of ſmall glands. The uppermoſt are ſmall ſimple glands, aſſembled together in a heap (CCVIII.), ſeated on the anterior and convex part of the epiglottis, upon the hollow ſurface of which they ſend out various openings, large ſinuſes and productions; and others are, in like manner, continued there in ſmall hard kernels. Moreover, upon the hollow anterior ſurface and back of the arytænoide cartilages (CCXCIV.), there are ſmall glandules placed on each ſide of a looſe conglomerate fabric, compoſed of little round kernels, doubtleſs muciferous, having ſome of their looſer parts extended on each ſide as low as the annular cartilage. In the cavity of the ventricles, there are very many mucous ſinuſes. Laſtly, all the internal ſurface of the larynx is full of large mucous pores. All theſe glandules ſeparate a thin watery mucus, which yet has a conſiderable degree of viſcidity.

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[83] The ſacks or receptacles found in ſome ſpecies of apes, are not to be confounded with theſe ventricles, which may be more or leſs inflated according to the will of the animal.

CCXCIX. It may be aſked, If the thyroide glandule has a like uſe, and is of the conglomerate kind, but ſoft and lobular, with many coverings, conſiderably large or broad in its extent, but of a more tender ſubſtance than the ſalival glands, ſeated upon the thyroide cartilage, and in part upon the cricoide cartilage and windwipe, along their fore-part, ſo as to encompaſs the lateral horns and ſides of the thyroides, joined to its companion, which is narrower, by an iſthmus, which is emarginated on the lower part, but aſcending upwards by a very thin proceſs before, in its middle part, as far as the os hyoides? This gland is full of a ſerous, yellowiſh, and ſomewhat viſcid humour: but whether it emits the ſame into the windpipe or into the œſophagus, is a queſtion; at leaſt there are no ducts certainly known to open into either of them. Whether or not the juices are altogether retained in this gland, and afterwards poured into the veins in a manner reſembling the fabric of the thymus, or whether it is of the conglobate kind, is uncertain. Yet that the uſe of this gland is very conſiderable, may appear from the largeneſs of the arteries which it receives from the carotides and lower ſubclavians. The veins thereof return their blood into the jugulars and ſubclavians. It has a peculiar muſcle, not conſtantly to be found, ariſing from the edge of the os hyoides, and ſometimes from the lower margin to the left of the thyroide cartilage, which deſcends without a fellow, ſpreading its tendinous fibres over the gland. Upon which alſo the ſternohyoidei and ſternothyrodei muſcles are likewiſe ſpread or incumbent.

CCC. The whole larynx is ſuſpended from the os hyoides by the ligaments proceeding towards the ſuperior horns of the thyroide cartilage, and perfecting that cartilage from the middle of its baſis to the conjunction of its plates. The ſame, together with the conjoined os hyoides, is capable of being raiſed conſiderably, at leaſt half an inch above its mean altitude. This is performed by the biventer muſcles, together with the geniohyoidei genioglоſſi, ſtylogloſſi, ſtylohyoidei, ſtylopharyngei, thyreopalatini, hyothyroidei; all or ſome of which conſpire together in that action. In this elevation the glottis is preſſed together or made narrower, and the ligaments beforementioned (CCXCV.) approach nearer together. But thus, by the aſſiſtance of the action of the arytænoide muſcles, together with the oblique and tranſverſe ones, the glottis may be accurately cloſed, ſo as to reſiſt with an incredible force the preſſure of the whole atmoſphere.

CCCI. The ſame larynx may be, in like manner, depreſſed to about half an inch beneath its ordinary ſituation, by the ſternohyoidei, ſternothyroidei, and coracohyoidei, as they are called; and, when theſe are in action, alſo by the joint force of the anterior and poſterior cricothyroidei. In this motion the arytænoide cartilages depart from each other, and render the glottis wider, which is alſo drawn open laterally by the muſcles inſerted into the ſides of the arytænoide cartilages, together with the crico-arytænoidei poſtici and laterales, and thyreo-arytænoidei: theſe may alſo compreſs the ventricles of the larynx (CCXCVII.) on which they are incumbent; the particular cartilages which make up the larynx can ſcarce be moved ſeparately.

CCCII. From the larynx the air comes into the mouth and noſtrils. By the mouth, we mean that large and irregularly ſhaped cavity between the ſoft and hard palate, both concave in the middle, and lower down parted between the muſcles which lie under, and the lower jaw. The noſtrils aſcend forwards above the ſoft palate; they are two broad cavities intercepted between the ſeptum medium, the oſſa cavernoſa, and various other bones. They are every where bony and cartilaginous.

CCCIII. The tongue lies in the middle of the mouth; and is a broad piece of fleſh eaſily changeable into any kind of figure, and thus readily moved without delay to every part of the mouth; moſt expeditiouſly directed into every ſituation, and made to aſſume any ſhape, by its own fleſhy fibres, and by the muſcles attached either to itſelf or to the os hyoides which is joined to it by many fleſhy fibres and membranes. In the fore-part theſe come from the geniogloſſi and geniohyoidei muſcles; backwards from the ſtyloglossi, ſtylohyoidei, ceratoglossi, baſiogloſſi, chondrogloſſi, and biventer; downwards, from the ſternohyoidei and ceratohyoidei; upwards, from the ſtylogloſſi, ſtylohyoidei, from the biventers, and likewiſe from the mylohyoidei.

CCCIV. Hitherto we have given the anatomy. It remains, therefore, that we demonſtrate, what action the air produces, when it is driven by the foreſaid powers (CCLXIX, CCLXX.) from the lungs in exſpiration through the windpipe into the larynx, and from them urged out through the glottis into the mouth, variouſly configured. The conſequences or effects of this are, voice, ſpeech, and ſinging. The voice, indeed, is only formed, when the air is expelled with ſo great a velocity through the contracted glottis, that it ſplits or makes a colliſion upon the ligaments of the glottis, ſo as to put the larynx into a tremor, which tremor is returned and continued or increaſed by the elaſticity of theſe parts. Sound, therefore, ariſes from the conjunct trembling of the ligaments (CCXCV.) together with the cartilages of the larynx at one and the ſame time, which we then call the voice, and is of a peculiar kind or modulation in every ſingle claſs of animals, depending entirely upon the difference of the larynx and glottis. But when a trembling is not excited, the exſpired air cauſes a whiſper.

CCCV. The ſtrength of the voice is proportionable to the quantity of air blown out, together with the narrowneſs of the glottis; and, therefore, a large pair of lungs eaſily dilatable, with an ample cartilaginous and elaſtic larynx and windpipe, and the free echo of the noſtrils, joined with a powerful exſpiration, all conduce to this effect. But acute and grave tones of the voice, we obſerve to ariſe from various cauſes. The former proceeds from a tenſion and narrowneſs of the glottis, and the latter from a relaxation and expanſion of it. For thus, in the former, a greater number of aërial undulations are ſplit in the ſame time upon the ligaments of the glottis, whence the tremors excited at the ſame time are more numerous; but when the glottis is dilated, the contrary of all this follows. And from the greater tenſion of the ligaments, the tremors in like manner become more numerous ftom the ſame ſtroke. Therefore, to produce an acute and ſhrill voice, the whole larynx is drawn upwards and forwards; and ſo much the more as the voice is required to be ſharper, inſomuch that the head itſelf is inclined backwards, by which the powers of the muſcles elevating the larynx are rendered more full and effectual. The truth of this is confirmed by experience, by applying the fingers to the larynx when it forms an acute ſound; for then, to raiſe the voice an octave, you will eaſily perceive it to aſcend near half an inch. Alſo the ſame is evident from comparative anatomy, which demonſtrate the narroweſt glottis and the cloſeſt approximation of cartilages in ſinging birds, but an ample or broad glottis in hoarſe animals and ſuch as bellow or bleat. An inſtance of this we have in whiſtling, where the voice manifeſtly becomes more acute by a contraction or narrowneſs at the mouth: alſo in muſical inſtruments, in which a narrowneſs of the mouth or opening that expels the air, with a celerity of the wind blown out, are the cauſes of an acute or ſhrill tone.

CCCVI. Gravity of the voice, on the contrary, follows from a depreſſion of the larynx by the cauſes (CCCI.) already deſcribed; to which add a broad glottis and a very ample larynx. This is evident to the touch of the finger applied to the larynx when a perſon ſings, by which the deſcent of it is manifeſtly perceived to be about an inch for every octave: hence the voice of males is more grave; and hence the loweſt degrees of the voice degenerate into a muteneſs or whiſpering.

CCCVII. Is the whole difference of tone owing to the length of the ligaments of the glottis, which is augmented when the ſcutiform cartilage is drawn forward, and the arytænoide ones backward? Is it according to this rule, that the moſt acute tones are produced, which ariſe from the ligaments being exceedingly ſtretched, and thus vibrating with great celerity? This has been confirmed by repeated experiments made by eminent men; and ſome late anatomſts have obſerved, that, when the chords or ligaments of the glottis are tenſe, the peculiar voice of every kind of animal is produced by blowing air into its larynx: that this voice was more acute as the ligaments were more tenſe, and more grave as they were ſlackened; that by ſhutting the whole ligament, the voice was ſuppreſſed; by ſhutting the half, the voice was rendered an octave higher; by ſhutting a third part, a fifth higher, &c. There are not wanting, however, doubts concerning this new theory, ariſing from the cartilaginous and bony ſtructure of the glottis of birds, which of conſequence muſt be immoveable, and not extenſible; from the voice moſt certainly becoming more acute, in whiſtling, from the mere contraction of the lips; from the example of women, in which the larynx is ſofter, but the voice more acute, than in men; from experiments which ſhow, that more acute ſounds are produced by bringing the ligaments of the glottis nearer into contact with each other, from the perfect want of machines, by which the ligaments can be ſtretched, and which may bring the ſcutiform cartilage forward from the annular one. But ſeeing it appears from experiments, that a tenſion of the ligaments ſuffices for producing acute ſounds, without the contraction of the glottis, we may believe that the different tenſion of the glottis contributes more to the diverſity of voice than the different diameter of it.

CCCVIII. *Singing* is when the voice, modulated thro' various degrees of acuteneſs and gravity, is expelled through the larynx, while it is trembling and ſuſpended betwixt two contrary powers; and herein lies the principal difference betwixt the chanting of ſimple notes, and the expreſſion of words. Hence it appears to be a laborious action, by reaſon of the continual contractions of the muſcles, which keep the larynx at an equilibrium: and hence it is, that ſinging makes a perſon hot; becauſe in acute tones the narrower glottis much retards the exſpiration, while at the ſame time a great deal of air is required to give ſtrength to the voice (CCCV.); to which, again, deep inſpirations are neceſſary. Hence likewiſe the windpipe is rendered very dry, from the quicker paſſage or current of air: to prevent which, a great deal of mucus is required; and therefore it is that there are ſuch numbers of mucous receptacles in the larynx, amongſt which I am firmly of opinion the ventricles before deſcribed (CCXCVII.) ought to be numbered.

CCCIX. *Speech* is performed by the larynx at reſt, or held in the ſame place, in tones of voice differing but little in acuteneſs and gravity: but then the voice is variouſly changed or modulated by the organs of the mouth. Singing has a variation in the tone or cadence of the voice, together with a modulation of it by the organs of the mouth at the ſame time.

CCCX. All ſpeech is reducible to the pronounciation of letters, which differ in various nations; but moſt of them are alike all the world over. Of theſe, ſome are called *vowels*, which are made only by an expreſſion of the voice through the mouth, without any application of the tongue to certain parts of the mouth. But conſonants are formed by a colliſion of the tongue againſt certain parts of the mouth, lips, and teeth. But to be more particular in theſe matters is beyond our purpoſe, which does not permit us to expatiate upon the beautiful art of pronunciation. That art, as an extraordinary inſtance of mechanical knowledge, has ſo accurately determined all the corporeal cauſes concurring to each letter, that, by inſpection only, with the aſſiſtance of touch, letters pronounced are underſtood without hearing them, and the attentive perſon is thereby taught to imitate the ſame ſpeech by a like uſe of the organs [84].

CHAP.

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[84] Man's faculty of ſpeech, the prettieſt artifice of nature, ſo often exactly imitated by art, involves a double conſideration; the philoſophical, which has given riſe to that academical queſtion, particularly deſcribed in the writings of Maupertuis and Suſſmilch; and the phyſical, or rather phyſiological, which treats of the mechanical cauſe of ſpeech from the ſtructure and fabric of the parts. With reſpect to the philoſophical conſideration of ſpeech, I would nevertheleſs not totally refuſe this faculty to other animals of expreſſing themſelves by ſigns, many of which depend upon the voice: it has been very elegantly, and even in ſuch a way handled, by the learned Herder who gained the prize, Tiedman, Tetens, Zobel, Platner, and others perhaps, that a phyſiologiſt himſelf reaps a great deal of information from the reading of their works. But upon conſidering the faculty of ſpeech without regard to the parts, and comparing man with other animals; infants with adults; civilized with uncivilized nations; man educated by man, with him brought up amongſt brutes; the learned with the ignorant; the man who hears, with the deaf and dumb; it is very probable, that the elegant phenomenon of the human ſpeech as well ariſes from the proper fabric of the organs, as depends upon the degree and perfection of knowledge. For there is innate in us even from infancy a ſtruggle and deſire to expreſs the feelings of the mind by ſigns; nay, there is that deſire in all animals; with this difference only, that men, beſides the affections of their

CHAP. XI.

Of the BRAIN *and* NERVES.

CCCXI. THE remaining actions of the human body we ſhall conſider according to the courſe of the blood. The coronary arteries we ſpoke of before, when we gave the hiſtory of the heart. Next to thoſe, the carotids paſs out from the aorta.

CCCXII.

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their mind, expreſs the want of things neceſſary to their life and defence, and the impreſſions which external objects make upon the mind, by ſigns, voice, and ſpeech; which faculty, however, brutes never acquire. Infants ſignify their impatience, unleſs we ſoon underſtand their ſigns, by mournful crying. I once ſaw an Ethiopian inhabitant of Gorea weep ſeverely becauſe nobody would take notice that a certain picture was pleaſing to him. The French ſoldiers in the late war, notwithſtanding the uſual gentleneſs of that nation, were greatly diſquieted when they found their language not underſtood. Now we ſee ſpeech ſuppoſes a concatenation of various circumſtances; the perception of idea; the neceſſity of expreſſing and ſignifying it by ſigns; the organs neceſſary for performing it; and the reaſon, cuſtom, improvement, and manner of uſing the inſtrument of ſpeech in a proper way. Therefore the primary foundation of ſpeech, and of the ſtore of languages and words, conſiſts in the copiouſneſs of facts and ideas, and in the extent of knowledge and learning. The phyſical ratio of ſpeech, by which we pronounce vowels and diphthongs, according to the determined conſtriction and opening of the fauces and mouth, and according to the ſpecific alliſion of the air upon the various parts of the mouth, palate, noſtrils, and teeth, and by the percuſſion of the tongue upon the ſaid parts, it is that we form the conſonants in general, as well as thoſe paticular to ſome nations; as *th* of the Engliſh, *lr* of the Chineſe, *mr* of Malabar, elegantly ſhow; and that the mechanical application of the inſtruments of the voice and ſpeech is preciſely requiſite to the pure and diſtinct pronunciation of this or that ſyllable or word, which Wilkins before, and Vogel lately, and de Broſſe, have learnedly demonſtrated. Hence were eaſy, but not leſs learned and wonderful, the atempts not only of remedying the various vices of the voice, ſuch as Codronch and Pujat have recounted; but what merits the greateſt admiration, of teaching perſons born deaf and dumb to ſpeak artificially. The celebrated maſters of this famous art, Petrus Pontius, whether he, or, according to others, Joh. Paul. Bonetus, is reckoned the firſt inventor of this art, Wallis, Holder, Amman, Raphel, Thumig, Kerger, Arnold, &c. made uſe of a double method and principle. For ſome, from the ſimple imitations of the mouth's changes, CCCXII. The aorta, which comes out from the anterior part of the heart (CLVII.), in order to bend itſelf towards the vertebræ of the thorax, forms there a conſiderable arch, by which it is bent backward, and towards the left, in an angle that is round, but not very large. From the convexity of this arch, three conſiderable branches ariſe. The firſt aſcends towards the right ſide, and is immediately ſubdivided into two large arteries, of which the lowermoſt goes on in the direction of its trunk, under the denomination of the *ſubclavian*. The other aſcends according to the courſe of the windpipe to the head, and is called the *right carotid*. The *left* carotid ſprings next from the ſame arch, a little inclined to the left ſide; and the third, which is ſtill more inclined to that ſide, is called the *left ſubclavian*, which is ſomething leſs than the right. About the origination of theſe arteries, the next continuous margin of the aorta is a little thicker and more protuberant. But variations from this courſe are rarely obſerved[85].

CCCXIII.

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changes, when once a word was uttered, and the letter being marked, if they heard a proper articulation, they uſed to bring their pupils to the uſe of ſpeech with incredible patience. But others in a more natural way firſt excited the attention of their pupils to objects, ideas, affections of bodies, and whatever they wiſhed or ought to expreſs by ſpeech; then the buſineſs being made eaſier, they learn to accommodate their voice to the deſignation of ſuch things. There are examples in infants ſufficiently manifeſt, that they expreſs more eaſily the name of a thing which they have conceived in their mind, whether it has been agreeable or diſagreeable; but you will ſcarcely learn the dumb, deaf, and ſtupid, without the greateſt patience and trouble, to pronounce a ſingle letter according to the firſt method, becauſe you ought firſt to correct the dulneſs of their ſenſes and mental faculties.

[85] In more than 600 ſubjects, which I have inſpected theſe ſeventeen years paſt, with reſpect to the branches coming out of the arch of the aorta, I only obſerved five varieties: the right ſubclavian alone deſcending from the aorta, with other three from the arch; the right ſubclavian and right carotid apart from the arch, therefore four branches; again, four branches from the arch; whilſt the left vertebral and left ſubclavian deſcended from the aorta with four branches from the arch, to wit, the vertebral and left mammary; and laſtly, between five branches, I obſerved the vertebral and inferior thyroid of the left ſide came out of the arch.

CCCXIII. The carotid artery, ſurrounded with a great deal of denſe cellulofity, together with the jugular vein and nerve of the eighth pair, commonly aſcends as high as the upper part of the thyroide cartilage without ſending off any branches. There it divides into two trunks. The anterior, called the *external* carotid, which is rather larger and more in the direction of its trunk, ſends off a branch called the ſuperior *thyroidea*, alſo the inflected arteria *lingualis*, and then the *labialis;* and from the poſterior face of the carotid the next artery which ariſes is the pharyngea aſcendens, which, beſides the pharynx and muſcles of the moveable palate, ſends likewiſe a conſiderable branch in common with the nerve of the eighth pair through the foramen of the jugular vein to the dura mater, very near to the great foramen of the occiput, at the baſis of the os petroſum, and which is divided at the cuneiform proceſs of the multiform bone.

CCCXIV. Again, from the edge of the external carotid, ſprings the *occipital* artery; which ſends branches not only to the muſcles which give it a name, but likewiſe ſends a branch through a peculiar foramen of the dura mater in the angle which the os petroſum forms by departing from the mamillary portion, which artery is ſpread through the ſeat of the cerebellum; another branch paſſes over the atlas to the dura mater under or into the ſkull; and a third ſometimes goes through the foſſa jugularis to the dura mater. The next artery, which is the *auricularis*, goes to the back part of the ear, to the temple, and to the membrane of the tympanum.

CCCXV. What remains of the external carotid artery, aſcends through the parotid gland, to which having given ſome branches as well as to the face and eye-lids, it ſends out the *temporalis*, which is conſiderable. The trunk of the carotid, being inclined, conceals itſelf behind the lower jaw under the denomination of *maxillaris interna*.

CCCXVI. In that place, it directly ſends off a large trunk, which paſſes to the dura mater through a peculiar opening[86] of the broad and pterygoide wings, ſeated at the middle foſſa of the brain; from whence they are largely ſpread through the temples and forehead within the dura mater, as far as the falciform ſinus. Sometimes this artery is double, and often gives out a branch that is conſpicuous to the lachrymal gland of the eye. In the ſame place, likewiſe, the maxillary artery enters the upper part of the nares by a threefold trunk, where it is ſpent after having given off the branches called *maxillares inferior* and *ſuperior* to the teeth, with the infra orbitalis to part of the face and eye-lids; and the palatina to the bone of the palate, with ſmall branches to the dura mater, and others through the ſmaller pores of the great wings, with ſuch as accompany the third and ſecond branch of the fifth pair of nerves; and laſtly, together with the dura mater, filling up the lower orbital fiſſure.

CCCXVI. But the other poſterior trunk, commonly called the *internal carotid* (CCCXIII.), aſcends without a branch. This artery having firſt made a conſiderable ſerpentine flexure enters through a peculiar foramen in the os petroſum, where it is ſurrounded with a capſule from the dura mater, like that which comes out through all the openings of the ſkull: from thence it aſcends upwards and inclined forwards, till, having penetrated into the cavity of the ſkull, it riſes up inflected and in a curvature, according to the direction of the ſella equina[87]; in the middle of which there is a cavernous or hollow ſinus retarding the blood: from thence, having given ſmall branches to the fifth pair of nerves, it ſends others to the fundibulum and dura mater, with one larger to the eye; part whereof returns again through a peculiar hole into the dura mater, which lies upon the middle of the orbit. This is the rete mirabile of beaſts, but not of man.

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[86] Commonly called the *ſpinal*, tranſmitting the arteria meningea media.

[87] In its paſſage through the canal of the os petroſum, it ſends ſome twigs, the number not conſtant, to the inner ear.

CCCXVII. But the trunk of this internal carotid paſſes over the anterior part of the ſella equina; and being incurvated backward, and received by the arachnoide membrane, giving branches to the pons and crura of the brain, with a circle to the choroide plexus, and one that accompanies the optic nerve, it then divides into an anterior and poſterior branch. The former, being conjoined with its fellow artery of the other ſide by a ſhort inoſculating branch, which ſometimes ſprings from the trunk itſelf, is then incurvated backward and upward, according to the direction of the os calloſum, and ſpreads itſelf about the middle and hinder part of the brain; where it ſometimes ſends branches to the falciform proceſs, and from the very origin of the third ventricle to the fornix and thalami. The latter, being conjoined by a ſmall inoſculating branch with the vertebral artery, unleſs that ariſes from the undivided trunk of the carotid artery, afterwards aſcends a long way upon the ſide of the brain through the Sylvian foſſa; and the ſame ſends branches to the choroide plexus. All the branches of the carotid, contained within the ſkull, are made up of more thin, ſolid, and brittle membranes, than the other arteries of the body.

CCCXVIII. But the *vertebral artery*, commonly ariſing from the ſubclavian of the ſame ſide, (though the left has been ſometimes ſeen to ſpring from the trunk of the aorta,) paſſes on without giving branches, through a place of ſecurity, till it enters a foramen in the tranſverſe proceſs of the ſixth vertebra of the neck; after which, it continues with alternate flexures to aſcend through the oblique proceſſes of the other vertebræ of the neck; from whence, at each interval, it ſends off ſmaller branches to the muſcles of the neck, and communicates with the lower thyroideal: other branches, again, ſomewhat larger, go from it backward, together with each of the nerves, to the pia mater of the ſpinal medulla; but before, the branches are larger, though leſs numerous, to the ſame ſpinal medulla, and communicate by an anaſtomoſis with its ſpinal artery anteriorly.

ly. Laſtly, growing leſs about the ſecond vertebra, and being inflected with a large curvature round the tranſverſe proceſs of the firſt vertebra, it there ſends off conſiderable branches to two of the muſcles of the neck: alſo ſmall branches it ſends off in its courſe through the great foramen of the occiput or ſkull to the dura mater, and the adjacent cavities that contain the cerebellum; after which it goes on through the ſaid foramen into the cavity of the ſkull. There aſcending, according to the courſe of the medulla oblongata, the right trunk by degrees approaches nearer to the left, and is conjoined together with it (in an extraodinary manner, hardly to be found in other parts) into an artery called the *baſilaris*, which is ſuſpended in the pia mater all along under the pons Varolii. From the vertebral arteries, before they are conjoined together, or from the trunk produced after the common manner, paſs out branches, which go to the lower ſurface of the cerebellum, and are deeply inſerted under the fourth ventricle to the inner ſubſtance of the cerebellum. Theſe ſend off the ſpinal arteries. But there are ſome inſtances where they ariſe conjunctly from a ſingle trunk; or from the trunk in one ſide, and a branch in the other. Then the baſilaris, beſides branches to the medulla oblongata and crura of the brain, gives the other lower arteries of the cerebellum. Amongſt the foreſaid branches alſo ariſes an artery, which accompanies the auditory nerve. Finally, the baſilaris, at the forepart of the pons, divides into two branches. One of theſe goes to the upper part of the cerebellum, to the fourth ventricle, to the crura of the medulla of the cerebellum, the nates, teſtes, and pineal gland: in place of this, alſo, there are two trunks. The other is divided to the loweſt part of the brain at its poſterior lobe, the choroide plexus, the plexus incumbent on the pineal gland, that gland itſelf, the thalami, corpora ſtriata, fornix, and whole anterior ventricle of the brain.

CCCXIX. From the foregoing hiſtory of the arteries belonging to the brain, it appears, that a very great quantity of blood is in every pulſation ſent to this organ, inſomuch that it makes above a ſixth part of the whole blood that goes throughout the body, and derived from trunks that are very near the heart, ſpringing from the convexity of the aorta. From hence it is probable, that the ſtrongeſt parts of the blood go to the head, and ſuch as are moſt retentive of motion. Is not this evident from the effects of mercurials exerting themſelves almoſt in the head only; from the ſudden force and action of inebriating ſpirits upon the head; from the ſhort ſtupor which camphor excites[88]; from the heat, redneſs, and ſweat, which happen oftener in the face than other parts of the body; to which add, the more eaſy eruption of volatile and contagious puſtules in the face? The well guarded paſſage of theſe great and important veſſels in their aſcent to the head, defends them from any great injury. The frequent inoſculations of one trunk, with the other going to the head, as well as the frequent communications of their branches among themſelves, leſſen any danger that might enſue from obſtruction. Hence, when the carotids are tied, the animal neither dies nor ſeems to be very uneaſy. The conſiderable flexures of the vertebral and carotid artery ſerve to moderate the impulſe of the blood coming to the brain, ſince a great part the velocity, which the blood receives from the heart, is ſpent by the various inflections. To which add, that ſome authors do not improperly obſerve that the arteries here grow larger or ſomewhat wider.

CCCXX. The hiſtory of the brain deſervedly begins from its integuments. Such a tender part, ſo neceſſary to life, we obſerve providently ſurrounded on all ſides, firſt by a ſphere of bones, conſiſting of many diſtinct portions; by which means it is rendered extenſible, at the ſame time that it is effectually guarded againſt external preſſure. To the internal ſurface of this bony ſphere, on all ſides, grows a very ſtrong membrane, compoſed of two plates ſufficiently diſtinct, which are firmly attached by an infinite number of ſmall veſſels, as by ſo many foot-ſtalks to the whole ſurface of the ſaid bones, ſo as to be nowhere eaſily ſeparable in a healthy perſon; theſe, being very thin and ſmooth, adhere leſs firmly to the bones, but more ſtrongly to the *ſutures*, ſo called from their figure, which join the bones of the ſkull one to another. In younger ſubjects, the adheſion of the dura mater to the ſkull is ſuch, that the ſeparation of it pulls off the fibres of the bones to which it is connected. In adults, many of the veſſels being effaced, renders it more eaſily ſeparable: yet it is not without ſome force, even in thoſe, that the dura mater can be ſeparated from the ſkull From the rupture of theſe veſſels, which enter the bones of the ſkull, appear thoſe bloody drops which are obſervable after removing the cranium. Hence appears the vanity of all that has been advanced concerning the motion of the dura mater. As to the motion which is remarked by the writers of obſervations upon wounds in this part; that, being preternatural, was the conſequence of the beating of the arteries (in a part where the reſiſtance of the bone was now removed, while the reſt of the dura mater next to the ſkull ſuſtained the force of the heart without motion); or of the brain ſwelling during exſpiration. Alſo that part, which is properly the dura mater, has neither nerves, nor ſenſation nor irritability[89].

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[88] All theſe arguments are not of the ſame force: for mercury applied in different ways to the body, produces its effect not in the head alone; ſince it occaſions in ſome a diaphoreſis, in others a diarrhœa, and in others it acts as a diuretic.

CCCXXI. The *outer plate* of the dura mater, which adheres to the bones of the ſkull, is to them inſtead of a perioſteum, and ſupplied with ſmall nerves and blood-veſſels coming through all the holes of the ſkull; from whence, and from its coheſion with the peri-

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[89] That nature has given none, or, what is liker truth, very few nerves to the dura meninges, I am convinced from Lobſtein's and my own obſervations; however, both inflammation and ſurgical phenomena forbid my denying, that this membrane is totally deſtitute of ſenſibility.

perioſtea of the head, ſpine, and whole body, it has received the name *mater*. The *internal plate* of the dura mater is in moſt parts continuous with the former: but, in ſome ſubjects, it recedes a little from it, as in the great ſphenoidal wings; and at the ſides of the ſella equina, where a good deal of blood is poured betwixt them; and they likewiſe recede thus upon the ſella equina itſelf: the ſame plate having left the outermoſt, adhering firmly to the bones of the ſkull, deſcends doubled together to form the falx, which ariſes firſt from behind the proceſſus criſtæ galli of the multiform bone, afterwards from the criſta itſelf, and from the whole junctures of the bones of the forehead and the parietals; and laſtly, it ariſes from the middle of the back part of the occipital bone, and, growing broader backwards, is interpoſed betwixt the hemiſpheres of the brain; the more remote part of it forward hangs over the corpus calloſum, and that which is next in the back-part is extenuated to an edge in the ſame place. That there are ſhining fibres in this part, diſperſed towards the longitudinal ſinus from the conjunction of the tentorium, in the ſhape of branches and palm-twigs, is certain; but it does not therefore follow that they have any muſcular motion; and betwixt theſe fibres frequently there is no membrane, only natural foramina are interpoſed. The falx is both joined to, and continued from, the middle tentorium, which is extended laterally. In the ſame manner, with ſome difference of ſituation, the ſaid falx ſends out a ſhort plate downward, which divides the cerebellum, together with the ſtrong tentoria or lateral productions; which ariſing from the cruciform protuberance of the occiput, are interpoſed tranſverſely betwixt the brain and cerebellum, extended as far as the limits of the os petroſum, and connected to the anterior clinoide proceſſes, leaving an oval aperture for the medulla oblongata to deſcend freely. Theſe productions of the dura mater ſerve to prevent the parts of the brain from preſſing one another, in all ſituations and poſtures of the body; and they likewiſe hinder one part of the brain from bruiſing the other, by any ſhock or concuſſion. Hence it is, that in the more active quadrupeds, where a concuſſion is more likely to happen, the brain and cerebellum are divided by a bony partition.

CCCXXII. In the external ſurface of the pia mater, not far from the ſinus of the falx, are placed ſmall glandules, ſeated in the reticular texture of the hard membrane, partly looking towards the ſinus, to whoſe cavity they are oppoſed, in ſuch a manner, that ſome of them are contiguous to the hollow of the ſinus; others are ſo placed at the inſertion of the larger veins into the pia mater, that, together with the former, they make up a continued range or ſeries; ſome are alſo obſerved in the tentorium of the cerebellum, which are ſometimes ſoft, oval, and white, ſometimes red, hard, and in appearance like wrinkles[90]. But the vapour, which exhales from the ſurface of the pia mater, is not ſeparated by theſe glands: for it is every where exhaled, even into the ventricles, where there are none of thoſe glandules; and it plentifully tranſpires every where from the mouths of the leaſt arteries, as we ſee by experience, when water or fiſh-glue are injected, which ſweat out through every point in the ſurface of the dura mater.

CCCXXIII. The next covering of the brain, which is more cloſe to it, and preſſes the whole ſurface of the brain, as that does the cavity of the ſkull, has been denominated from its tenuity, *arachnoides*, i. e. like a ſpider's web. This very thin or tender membrane, being pellucid like water, every way ſurrounds the brain, whoſe inequalities it climbs over, and according to its extreme thinneſs is pretty ſtrong, and ſurrounds the larger veſſels in ſuch a manner, that the ſaid veſſels ſeem to run between the pia mater and arachnoides; which

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[90] So called glands by Pacchioni; frequently found in great numbers between the two layers of the dura meninges, for the moſt part in the duct of the falciform ſinus; they occupy a broad ſurface; their uſes are not yet ſufficiently known; they belong rather to the conglomerate, than to the conglobate glands.

laſt is, therefore, no part or lamella of the pia mater, from which it differs by ſituation, and is connected to it by a cellular texture after the manner of the ſpinal marrow, although it is reſolved into a cellular nature between the hemiſpheres of the brain.

CCCXXIV. The third or innermoſt covering of the brain, which is ſoft and cellular, is properly the *pia mater*[91]. This immediately inveſts the whole ſurface of the brain and ſpinal marrow on all ſides, is tender, and made up of a vaſt number of ſmall veſſels which are joined together by a cellular texture: but theſe veſſels it ſends into the brain in a regular order, like little roots. This deſcends betwixt every furrow and fiſſure of the brain and cerebellum, and even inſinuates itſelf into the ſpinal medulla, and is the bond by which the little protuberances of the brain are joined together. This being received into the cavities of the brain, changes its fabric, ſo as to become ſoft and almoſt of a medullary conſiſtence, more eſpecially when the ſubject that comes under the examination of the knife has lain dead ſome conſiderable time, yet then it is eaſy enough to demonſtrate the veſſels themſelves in its fabric.

CCCXXV. The *veins* of the brain are not diſpoſed in the ſame manner with thoſe in other parts of the body. For neither have they any valves, nor do they run together in company with the arteries, nor have their trunks the ſtructure which is commonly obſerved in the other veins. The veins, therefore, which come out of the innermoſt cavities of the brain, thoſe which are ſpread upon the ſtriated bodies, the veins of the choroide plexus, with the lucid ſeptum and the anterior ventricles, are collected together into trunks which at laſt meet in one great vein, or often two, which, being accompanied with many ſmall arteries of the choroide plexus, deſcends backward to the partition of the brain and cerebellum. In that place, it receives veins ariſing from the poſterior and lower part of the brain, and ſome of the cerebellum, from whence the blood paſſes into a ſinus, which is a kind of vein included in a reduplication of the inner plate or membrane of the brain, into which the veins, to ſhorten their length, are generally inſerted; and this ſinuous vein generally deſcends to the greater ſinus on the left ſide, though ſometimes it ends bifurcated, one branch on each ſide. This is called the *fourth* ſinus.

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[91] Deſerving the name of *vaſcular membrane*, ſince there is no membrane found in the body ſo fully ſupplied with veſſels.

CCCXXVI. The upper and ſuperficial veins of the brain are large, and ſpread in the windings with which the brain on all ſides abounds. With thoſe veins, thro' the whole ſurface of the brain, are inſerted other veins of the dura mater; and others, which enter by peculiar orifices into the falciform ſinus. From thence the veins, gradually collected together, paſs along, moſt of them forward, ſome few of them in a ſtraight direction, and others backwards; of which thoſe forward are the largeſt, and open themſelves, their extremities being obliquely cut off, into the long *falciform ſinus* which is formed by the right and left plate of the internal membrane of the dura mater, which meet together below upon the upper part of the back of the falx. From thence it is of a triangular figure, convex in its upper ſide, beginning with a ſlender origin at the ſeat of the foramen cæcum, that is placed above the criſta galli; from whence it aſcends and follows the courſe of the falx until that joins the tentorium: it is generally inclined to the right ſide, and takes the name of the *right tranſverſe ſinus*, which then goes by a peculiar channel in the occipital and temporal bone, tranſverſely to its incurvation at the opening of the jugular vein; in which place being much enlarged, it receives the lower ſinus petroſus, together with the occipital ones, which are hereby diſcharged into the jugular vein. But the left tranſverſe ſinus reſembles the former; and is, like that conveyed in a ſimilar courſe to the jugular vein, into which it is rather inſerted on the right ſide, than continued as it were in a trunk. Into it the fourth ſinus (CCCXXV.), together with the occipital one, uſually inſert themſelves. But there are ſome inſtances, where all theſe are diſpoſed in a different manner, by an inſertion of the longitudinal into the left tranſverſe ſinus; and then the right tranſverſe ſinus receives the fourth and the occipital one. At other times it is equally divided into two tranſverſe trunks; and ſometimes the middle ſinus joins the tranſverſe ones. The two ſinuſes alſo have been found ſimilar and parallel to each other.

CCCXXVII. There is a ſlender and rounder ſinus, which runs along the lower and thicker margin of the falx, ſomewhat of an irregular figure, more reſembling a vein, receiving veins from the falx itſelf, and communicating likewiſe with the upper ſinus; it alſo receives veins from the adjacent hemiſpheres of the brain, and from the corpus calloſum. Where the tentorium joins with the forepart of the falx, this is commonly there inſerted into the fourth ſinus.

CCCXXVIII. The *lower veins* of the brain which lie next to the baſis of the ſkull, are variouſly inſerted. The foremoſt of them coming from the foſſa ſylviana, collected together into ſome trunks, are inſerted into the cavernous ſinus, or triangular interval, that lies at the ſide of the ſella equina, betwixt the external and internal plate of the dura mater. Other veins, from the pons itſelf, lead into the upper ſinus petroſus. Other poſterior veins, which come from the poſterior lobes of the brain, are inſerted in great numbers into the tranſverſe ſinus that is ſeated within the tentorium.

CCCXXIX. The upper veins of the cerebellum meeting together in large trunks, partly open themſelves into the fourth ſinus, and in part into the tranſverſe ſinus. The lower veins from the cerebellum and medulla oblongata, inſert themſelves into the upper ſinus petroſus; the later alſo into the tranſverſe proceſs very near the place where it goes out.

CCCXXX. There are many ſinuſes, beſides thoſe before-mentioned. The moſt anterior of them, which is commonly *like a circle*, is larger behind than in its fore-part, which is ſlenderer, and ſurrounds the pituitary glandule betwixt the clinoide proceſſes, communicating with the cavernous and with the lower petroſe ſinuſes; likewiſe communicating betwixt thoſe proceſſes and the carotid artery, and again, by the way of the ſixth pair, with the upper petroſe ſinuſes behind the fifth nerve. There are ſome inſtances where this ſinus receives the ophthalmic vein; and ſometimes the tranſverſe, joining to the cavernous ſinus, ſupplies the place of this circular ſinus, or elſe is preſent with it at the ſame time.

CCCXXXI. The *upper petroſe ſinus* is conveyed backwards in a cavity of the os petroſum, and takes its origin from the extremity of the anterior ſulcus of the os petroſum, where it communicates with the cavernous ſinus, and receives the inſertions of the veins of the dura mater, and ſometimes of the anterior veins of the brain itſelf, mentioned before (CCCXXVIII.); then it is inſerted into the angle of the tranſverſe ſinus, where it begins to be bent; ſometimes alſo it joins the inferior ſinus of the os petroſum. Another vein, likewiſe deſcending by the os petroſum, is in like manner inſerted into the angle of the tranſverſe ſinus. The *lower ſinus petroſus*, which is larger, goes round the root of the bone of this name, and communicates with its fellow behind the clinoide proceſs; alſo twice it communicates with the cavernous ſinus, and with the upper ſinus, and is conjoined under the nerve of the fifth pair, being finally inſerted into the jugular foſſa or cavity. Moreover, it receives ſome veins of the dura mater from the baſis of the vertebræ. To the ſame outlet alſo the *occipital ſinus* leads on each ſide, which being pretty large, goes round the margin of the foramen, till arriving at the falx of the cerebellum (CCCXXI.), it is ſooner or later inſerted together with its fellow, for the moſt part into the fourth ſinus, and with that into the left tranſverſe one, or into the longitudinal ſinus itſelf, or laſtly by a divided extremity into each of the tranſverſe ſinuſes. This ſinus receives the lower and poſterior veins of the dura mater, and ſome others from the vertebræ.

CCCXXXII. The *anterior occipital ſinus* is irregular or multiform, partly tranſverſe, and partly deſcending to the great foramen, being variouſly conjoined with the lower petroſe ſinuſes: from whence it paſſes with the nerves of the ninth pair; and either communicates through a peculiar foramen, by emiſſaries into the outer vertebral vein; or other branches, going downwards, open into the venous circles of the ſpinal medulla. But the *cavernous ſinus* of the dura mater (CCCXXV.), being ſurrounded with a good deal of cellular ſubſtance, receives, beſides the forementioned ſinus (CCCXXIX, CCCXXX), large veins already deſcribed; alſo the ophthalmic, and principal vein of the dura mater; and tranſmits them with peculiar veins, together with the firſt and ſecond nerve, and third branch of the fifth pair, with a large artery of the dura mater (CCCXVI.) and the internal carotid (CCCXVI.): alſo it ſends out other emiſſaries through a foramen, which is not conſtant in the great wing, which form inoſculations with veins placed on the outſide of the ſkull leading to the jugulars, and eſpecially with the largeſt pterygoidal plexus of veins belonging to the noſe. In the ſame manner, the veins of the pericranium paſs through ſmall holes in the parietal bones into the longitudinal ſinus, as the occipital veins paſs through the maſtoide hole into the tranſverſe ſinus through the anterior channel of the occipital bone, and the external vertebral veins are inſerted into the jugular ſinus; and others of the anterior occipital veins accompany the nerve of the ninth pair. Thus there are an infinite number of ways open to the blood; by which it may paſs from the ſinuſes, wherein it is often collected in too great quantity by various directions, according as the part is more lax or has a greater declivity. Hence no violent ſymptoms follow upon tying either or both of the jugulars or other large veins.

CCCXXXIII. The great quantity of blood which goes to the brain, the greater impulſe with which it is ſent into the carotid arteries (CCCXIX.), and the ſecurity of this part from every kind of preſſure by a ſtrong bony fence, joined with the ſlower motion of the blood through the abdominal viſcera and lower extremities, alſo the perpetual exerciſe of the brain and ſenſes, do all determine a copious flux of blood to theſe parts, and ſome other cauſes ſerve to fill the head ſurpriſingly with blood. Hence it is that a redneſs of the face, a turgeſcence and ſparkling of the eyes, with a pain and pulſation or throbbing of the arteries in the head, are ſo frequently followed with a bleeding at the noſe, by violent exerciſes or motions of the body. From hence, therefore, it is evident, that if the veins were of a thin and round ſtructure in the brain, they would be unavoidably in greater danger of breaking, and conſequently apoplexies (to which, in their preſent ſtate, they are often liable) would be much more frequent. To avoid this, therefore, nature has given a different figure to the veins which carry out the blood from the brain, by which they are more eaſily and largely dilatable, becauſe they make an unequal reſiſtance: their texture is likewiſe very firm, and more difficultly broken, eſpecially in the larger ſinuſes, which perform the office of trunks; for as to the ſinuſes of the leſſer ſort, they are either round, half cylindrical, or of an irregular figure. Beſides this, nature has guarded the ſinuſes by croſs-beams, internally made of ſtrong membranes, and detached from the right to the left ſide within the ſinus, which in greater diſtenſions they draw towards a more acute angle, which is capable of a larger dilatation, ſtrengthening and guarding it from a rupture at the ſame time She has likewiſe, in theſe veins, provided numberleſs inoſculations, by which they open mutually one into another, and openly communicate with the external veſſels of the head and with thoſe of the ſpinal medulla, by which means they are capable of freeing themſelves more eaſily whenever they are overcharged with blood, (CCCXXXII.)

CCCXXXIV. It is by ſome queried, Whether a part of the arterial blood is not poured into the ſinuſes of the brain; and whether they have not a pulſation excited from that blood? That they have no pulſation, is paſt doubt; becauſe the dura mater every way adheres firmly ly to the ſkull, but much more firmly in thoſe parts which are the ſeats of the ſinuſes. Indeed they receive liquors injected by the arteries; but whether thoſe tranſude through the ſmall exhaling arterial veſſels, or whether they firſt make a complete circle through the veins, as indeed is much more probable, we are not yet furniſhed with experiments enough to determine.

CCCXXXV. Thus all the blood of the brain is finally conveyed into the jugular veins, which are very dilatable, and for that reaſon guarded with valves to prevent a return of the venous blood from the right auricle, being at the ſame time ſurrounded with a good deal of cellular ſubſtance. As to the blood which goes from the head to the vertebral veins, it is a very inconſiderable quantity; but the jugulars anſwer in ſuch a manner to the great upper vena cava in a direct courſe, that they afford the highway for the blood to return back to the heart. The branches of theſe are commonly the ſame with thoſe of the brain; namely, the veins of the brain, and thoſe of the face.

CCCXXXVI. The external jugular is a cutaneous vein of the neck, which produces the temporal one, and is united with the internal jugular at the baſis of the lower jaw; and the ſame ſends a branch through the os maxillare into the tranſverſe ſinus. The internal vertebral empties itſelf through the tranſverſe proceſſes of the neck into the tranſverſe ſinus as often as the canal belonging to it is opened.

CCCXXXVII. The two lateral ſinuſes of the ſpinal marrow run along its whole length, are joined to each vertebra by a ſemicircular arch, and at laſt are united with the jugular and occipital ſinuſes: they ſend branches, however, to the ſpinal marrow, joined with the anterior and poſterior ſpinal vein.

CCCXXXVIII. The veins form innumerable anaſtomoſes with one another, that the blood may return with the greateſt eaſe from the head, of which the repletion is very dangerous. The brain is alſo more eaſily evacuated in the time of inſpiration, and ſubſides as we ſee when the ſkull is opened, but ſwells during the time of exſpiration. Hence, blowing the noſe, ſneezing, and coughing, aredangerous to thoſe whoſe brain is ſwelled by retained blood.

CCCXXXIX. Whether or not there are lymphatic veſſels to be ſeen in the brain, is by ſome queſtioned. Indeed, we read deſcriptions of them in the pia mater, and in the larger choroidal plexus; but, for my own part, I have never been able to ſee them, and poſſibly there are none to be ſeen, ſince there are no conglobate glands in the brain, which are always near at hand wherever any of theſe veſſels are to be found[93]. As for the various accounts which are given of the pituitary glandule, of the infundibulum, and of the ducts which lead from thence into the veins of the head, abſorbing and tranſmitting a water from the ventricles of the brain, they are not ſupported by anatomical experiments: which makes it more probable, that the vapour which is ſecreted into the ventricles of a healthy perſon is, in like proportion, abſorbed again by the inhaling veins; or, if any part abounds, that it deſcends through the bottom of the ventricles to the baſis of the ſkull, and from thence into the looſe cavity of the ſpinal medulla. That this is the caſe, appears from palſies which enſue on one ſide of the body after apoplexies; and from the bifid ſpines or watery tumours in the lower part of the ſpinal medulla, following in thoſe who have an hydrocephalus.

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[93] In almoſt no viſcus has the exiſtence of lymphatic veſſels been oftener aſſerted and again denied, than in the brain. Although, indeed, I am fully certain, that a group of lymphatic glands is nowhere found without lymphatic veſſels, by no means, however, could I aſſert, that there are nowhere lymphatic veſſels where glands do not appear. By analogy drawn from the whole body and all the viſcera, I am lead to think, that the brain is not deſtitute of its aqueous veſſels, and that they run in particular upon the ſurface, not in the heart of its ſubſtance, although I myſelf have never ſeen any, but thoſe moving on the choroid plexus towards the tentorium, and on the inner ſurface of the dura mater, in the duct of the ſuperior longitudinal ſinus. But I cannot diſcredit the induſtry of the celebrated Sommering, who confirms the obſervations of King, Collins, and Pacchioni, who ſaw them going upon the pia mater. I would aſk, May they be joined with the glands of Pacchioni? May theſe corpuſcles ſupply the place of lymphatic glands?

CCCXL. It now remains for us to ſpeak of the encephalon itſelf[93]. But many are the parts included under this general denomination. By the *brain*, properly ſo called, we underſtand that upper and ſoft viſcus which is contained in the ſkull, and which is lodged by itſelf in its fore part; but backward it is incumbent over another conſiderable part, called the *cerebellum*, which lies in the poſterior and lower cavities of the occipital bone, under the membranous tentorium, which parts it from the brain. Its lower, middle, and white portion, deſcending before the cerebellum, is in part called the *pons*, and in part the *medulla oblongata.*

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[93] The brain, under which name we comprehend the cerebellum, crura, pons, and medulla oblongata, has it in common with all the viſcera, that, according to the diverſity of age, the condition and mutability of functions, in the various claſſes, genera, and ſpecies of animals it has its proportion, which varies prodigiouſly, to the body. Nobody will queſtion that the functions of the mind, the ſenſual faculties, and the more eaſy or difficult riſe and impreſſion of ideas, both occaſioned by theſe laſt agents, as well as by cuſtom and imitation, owe a dependence upon this different proportion of the brain to the reſt of the body. The dignity of ſuch diſquiſitions, and a peculiar fondneſs and deſire towards medical pſychology, prompted me, theſe eighteen years, whenever an occaſion preſented, in different animals, and in more than three hundred human ſubjects, to make inquiry in determining the proportion of the parts of the brain to one another and to the reſt of the body, and that of man to various brutes, paying regard to the weight as well as to the ſpecific gravity. Since the year 1766, I have ſeveral times communicated to my hearers, both in my medico-pſychological, and particularly anatomical lectures, many obſervations, both upon the weight and the increaſe of the medullary and diminution of the cortical ſubſtance, and likewiſe the increaſed ſpecific gravity of the brain. Hence many of my thoughts, my name, however, ſuppreſſed, were copied and inſerted in various philoſophical deſcriptions; but ſome errors crept in amongſt them: to amend which, I ſhall ſoon inſert a compendium of my obſervations, ſince the proper tables containing more than 500 experiments, do not ſuit this place. Haller has given a great catalogue of the weight of the brain and its proportion to the whole body, and containing the weight of ſeveral animals, taken from Schneider, Pezzi, Paris Tranſactions, the famous Buffon, Chalder, &c. but my obſervations will come in more properly, chap. xvii.

CCCXLI. The *figure* of the brain reſembles that of half an egg, which is deeply divided longitudinally, but not cut through above half way, into hemiſpheres reſembling the fourth part of an egg. Both the upper and lower ſurfaces are full of many gyri or convolutions, which pretty deeply cut or divide the brain with round ends or angles into undulated portions. But the largeſt is that which aſcends on both ſides outwards from the ſides of the ſella turcica, and divides the hemiſphere into two lobes. Upon the ſurface of the ſaid lobules or portions lies the *cortex*, extremely ſoft, and inclined from a yellow or red to a grey or aſh colour, being the moſt tender of all parts in the human body: this inwardly is filled with the *medulla*, which is almoſt perfectly white, but redder in the fœtus; in many places, it is perforated by red arteries, which are more ſimple and perpendicular, or ſtraight, than in other parts. This medulla is more ſolid and more capable of ſuſtaining its figure, notwithſtanding it is very ſoft, and abounds in a greater quantity than the cortex[94]. The greater poſterior branch of the carotid artery (CCCXVII.) firſt divides the right and afterwards the left hemiſphere of the brain into an interior lobe, which is the larger; and a poſterior lobe, which is the leſs.

CCCXLII. The fabric of the cortex has been a long time controverted; but it is now ſufficiently evident, from anatomical injections, that much the greater part of it conſiſts of mere veſſels, which are every way inſerted from the ſmall branches of the pia mater, detached like little roots into the cortical ſubſtance, and conveying a juice much thinner than blood in their natural ſtate, although in ſome diſeaſes, and by ſtrangling, they often receive even the red parts of the blood, more eſpecially in brutes and birds. The remaining part of the cortex, which is not filled by any injection, is probably either an aſſemblage of veins, or of yet more tender veſſels; for no other diſſimilar parts are apparent in the cortex, whilſt it is in an entire or natural ſtate; from whence one may conjecture ſome part of it to be tubular, and the other part ſolid. As to glandules making the fabric of the brain, that notion has been diſcarded by univerſal conſent; nor indeed has there been any other opinion received with leſs probability than this.

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[94] Whoever accurately inſpects the human brain, will find a threefold ſubſtance, particularly in ſuch brains as have been indurated by a mixture of alchohol and nitrous acid.

CCCXLIII. In order to gain a knowledge of the nature of medulla, we are to conſider the anatomical ſtructure of this part of the human brain, compared with the brains of brute animals and fiſh. Therefore this part of the brain, which follows immediately under the outer gyri or convolutions of the cortex, is of a white colour, and becomes gradually broader and more abundant; ſo that, at length, it makes up the whole oval ſection of the brain, except only the gyri in the ſurface, which makes the cortex. In this part, the two hemiſpheres of the brain, as before obſerved, are divided but half way through; which hemiſpheres here continue their coheſion with the medulla in the middle. That part of the medulla which is extended under the falciform proceſs, but at ſome diſtance from it, is called *corpus calloſum;* in the ſurface of which run two parallel white ſtripes, formed by the pulſation of the arteries: theſe ſtripes diverging forwards, and terminated at the place where they mingle together in the fore-part, are thence divided backwards. But the anterior extremity of this callous body is loſt in the ſubſtance of the crura, coming from the anterior lobes of the brain: the poſterior, which is broader, with a ſhorter curvature in the ſhape of a nail, is brought inwards; and the other column deſcends into the inferior horn of the ventricle, whence it is continued along with the longer one into the hippocampus. Moreover, the whole ſurface of this callous body is ſtreaked with tranſverſe fibres, which are continued, but extenuated, into the next adjacent medulla of the brain itſelf. Even the interior ſubſtance of this body is of a ſtriated nature, and its lower ſurface has its ſuture and fibres tranſverſe.

CCCXLIV. As to the remaining parts of the brain, a ſcrutiny is more difficult to be made into them: for the brain is not a ſolid body, but begins to be hollow internally from the lower part of its medulla, which is incumbent upon the multiform bone, at which place the greater crus of the brain paſſes out from it; and in this cavity the medulla is only covered with the pia mater, which aſcends backward, and then turning continues its courſe forward and upward. Next, the brain divides itſelf near the poſterior extremity of its callous body; and, at the ſame time, ſends one of its ſhorter poſterior portions into the poſterior lobe of the brain, turning its extremity inwards. But the anterior portion is continued a long way by the ſide of the callous body, parallel to the horizon; and turning its horn outward, which there grows broader, it is terminated in the anterior lobe of the brain. This cavity, of which there is one in each hemiſphere of the brain [95], is called its triangular or anterior *ventricle;* and it is naturally filled with a vapour, which is frequently condenſed into water or jelly.

CCCXLV. This cavity is full; ſo that the upper and lower parts of the brain meet together. The lower ſide or pavement of this part is variouſly figured. In its forepart, it forms a horn; below which there is a riſing moderately convex, and of conſiderable length, diverging backwards, covered with a membrane that is extremely vaſcular; and, being outwardly of an aſh or grey colour, is called the *corpora ſtriata;* becauſe inwardly they exhibit to the view, together with much cortex, alternate white oval ſtreaks, parallel to one another, longer on the back part; beſides, as it were, leſſer me-

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[95] It is quite joined under the margin of the lower fornix, ſo that water and mercury, injected from the one cavity into the other, has a free tranſition.

medullary ſpots and micæ. More inwardly and backward, there are two other ſimilar eminences, more of an egg-like ſhape, towards the third ventricle and other parts, moſtly cineritious on the outſide, obſcurely ſtriated, and ſo incumbent together, that they frequently cohere on the upper part, where they are confounded with the cortex: and theſe, continuing their courſe through the horn of each anterior ventricle, deſcend to the baſis of the ſkull, and there generate the optic nerves, of which they are called the *thalami*. Betwixt the ſaid ſtriated bodies and thoſe thalami, lies an intermediate, parallel, white, and ſtreaked medullary portion, called the double ſemicircular centre, produced from the *anterior commiſſure*, and frequently from the crura of the fornix; but eſpecially from the medulla itſelf, before the thalami of the brain. This commiſſure is broad, ſtrong, and joins together the anterior part of the brain before the thalami. The double centre, which is broadeſt behind, ariſes with many fibres, from the junction of the foot of the hippocampus with the medulla of the brain. But the corpora ſtriata, with the thalami, conſtitute the medullary crura of the brain; which, in the baſis of the cerebrum, lie over the medulla of the cerebellum, and are joined together at the extremity of the bridge above-mentioned. At the place where they approach neareſt to one another, each ſends out an hemiſpherical mamillary eminence. The fibres of the medulla of the brain itſelf, mixed together with the medulla of the cerebellum, deſcend into the medulla oblongata; and, being then collected into a bundle, they go to the corpora pyramidalia.

CCCXLVI. It is to be obſerved, that the corpus calloſum medium projects or riſes up in the common axis or middle of thoſe ventricles. Behind, this body lies contiguous and incumbent on the fornix; but, before, there are two ſimilar medullary partitions, which deſcend from this body the whole length of the corpora ſtriata; and this part, which in its middle includes an anonymous cavity, goes under the name of *ſeptum pellucidum*[96]. This ſeptum is continued to the *fornix;* that is to ſay, the four-horned medullary trabecula, which takes its anterior origin from the medulla of the brain, and ſometimes from the mamillary protuberances, and the commiſſure which we have mentioned; and behind that, particularly under the thalami, and often from the double centre and crooked line of the thalami. This fornix is incumbent upon an interval of the ſtriated bodies, and upon another interval of the thalami: from whence it degenerates, partly into a broad thin fimbria; and partly into another tubercle, which is evidently continuous with the fornix and callous body of an half cylindrical figure, and furniſhed with an appoſite *fimbria.* Theſe deſcend into the lower anterior horns of the ventricles; and at laſt terminate outwards by a ſort of convex ſulcated end, imprinted by the gyri of the brain; and terminated by a foot, having as it were four-furrows, whence the name of *hippocampus*, which externally are covered by exceeding thin medullary plates, but are inwardly of a cortical ſubſtance. At the beginning of the diviſion of the foot of the hippocampus, the tænia ends in two white ſtriæ, a long and a ſhort one, inſerted into this foot and into the brain, or one inſerted into the inmoſt part of the unguis. A like protuberance is continued in the poſterior horn of the ventricle, crooked inwards at its extremity like the claw of a bird, to which a continuous column occupies the hinder part of the baſis of the horn of the deſcending ventricle, which is continued with the corpus calloſum. Betwixt the departing poſterior crura of the fornix, the medullary portion, which is behind the middle plexus of the ventricles, and painted with tranſverſe and palmated ſtreaks, is called the *pſalterium* or harp.

CCCXLVII. Within the anterior or lower part of each

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[96] This cavity, which I uſe to call *ventriculum ſepti lucidi,* communicates with no other ventricle of the brain. I have ſeen it wonderfully dilated in an internal hydrocephalus, containing two drams of fluid.

each of the ventricles, begins the vaſcular *plexus*, called *choroides*, included in the pia mater only, it lying naked in the reſt of the cavity of the ſkull, made up of a great many ſmall arteries CCCXVII, CCCXVIII.), together with little veins originating from the larger trunk (CCCXXV.); all which numerous veſſels, joined together by the pia mater, reſemble a curtain variouſly folded. With theſe are intermixed many ſmall pellucid glandules of a round figure, reſembling hydatids. It aſcends from the baſis of the brain, through the deſcending horn of the ventricle, and thus is dilated as it goes upward; but, thence, becoming narrower, it goes on with the optic thalamus, to the poſterior extremity of the ſeptum lucidum. When thoſe plexuſes have reached the anterior extremity of the thalami, being afterwards reflected and united together into one very large vaſcular plexus, they gradually deſcend through the crevice of the third ventricle as far as the pineal glandula, and then are continued into the pia mater of the poſterior lobes of the brain. From this plexus, doubtleſs, proceeds the internal warmth of the brain, with its exhalation and inhalation. But the choroidal plexuſes become very broad where the anterior ventricles of the brain begin to deſcend; and thence, contracting gradually downward, they project their extremities to the ends of the anterior ventricles, covered only with the pia mater.

CCCXLVIII. Betwixt the thalami, applied one to the other almoſt with a plain ſurface, there is a natural fiſſure terminating the crura of the brain, which meet together in the baſis of the ſkull; and this is called the *third ventricle*. It leads by a declivity, like a funnel, forward into a concave column; which though hollow in brutes, is yet evidently leſs tubular in man, and connected to the pituitary glandule.

CCCXLIX. This is compreſſed on both ſides, ſimple, of uncertain ſtructure; on the anterior part almoſt round, and of a reddiſh colour; on the poſterior, cineritious,

ritious, broad tranſverſely, covered with the pia mater of the brain: it lies upon the proper impreſſion of the ſella turcica, and ſeems to be a kind of appendix to the brain.

CCCL. Backward, the thalami are conjoined together in the bottom of the ventricle, by a medullary faſcia, or poſterior commiſſure, and by a ſmaller tranſverſe chord; from which a crooked white ſtreak goes out on both ſides in the upper part, which loſes itſelf in the double centre, in the anterior commiſſure, and ſometimes in the crus of the fornix. On the fore and upper part, the thalami ſpring out of a protuberance, which is formed by the triangular fornix lying between the two thalami.

CCCLI. This little eminence ſeparates the upper triangular cavity of the third ventricle, filled up with the fornix, from the inferior calamus ſcriptorius, in ſuch a manner, that the cavity is continued both from the anterior and poſterior extremity of the third ventricle, from the top to the bottom. But even the anterior commiſſure is a medullary ſtreak which unites the thalami before the anterior crura of the fornix.

CCCLII. Again, behind the thalami, thoſe tranſverſe figured eminences of the medulla meet together, which conjoin the medulla of the right and left poſterior lobes of the brain. In this part, backward, are cut out four oval eminences, which are outwardly ſmaller, called the *nates* and *teſtes*, and which are of a ſubſtance inwardly cortical, but outwardly medullary. Upon theſe is ſeated a cortical glandule, ſomewhat oval and conical, ſpread with many ſmall veſſels, into which the choroide plexus here degenerates: this is the *pineal glandule* ſo much celebrated, and ſo frequently diſeaſed, and joined to the brain by ſmall foot-ſtalks ſent into the linea alba thro' the thalami in their paſſage forwards Between this eminence, on which theſe four protuberances are cut out, and the crura of the oblong medulla, paſſes a groove or channel in the ſame direction from the third to the fourth ventricle, manifeſtly open, reſembling an aqueduct[97].

CCCLIII. The whole medulla of the brain is, in its lower part or baſis, collected together into two very thick compreſſed columns, diſtinguiſhed in their ſurface by a line running according to their length; which have internally a cortical ſubſtance, and are the *crura of the brain.* Theſe, meeting together backwards, are covered by the ſubjacent crura of the cerebellum, and are inſerted by apparent ſtrata of fibres into the pyramidal bodies of the medulla oblongata; and with the other deeper fibres, which ſeparate the inner tranſverſe fibres that come from the cerebellum from the preceding, meet together with the medulla cerebelli to make up the beginning of the medulla oblongata.

CCCLIV. The *cerebellum*, as it is leſs, ſo it is more ſimple than the brain. It has two lobes, but no where deeply parted, united above and below in their centre to a ring of the ſame fabric with itſelf, called the *vermis*, at the ſide of which there is a ſmooth eminence of the ſame nature with the cerebellum itſelf. This part of the encephalon contains a great deal of the cortex, with a leſs proportion of medullary ſubſtance. And here likewiſe, the cortex is placed in the circumference, but marked with gyri or convolutions, which are rather parallel to each other, ſo as to form circles. Thus the ſmall lobules or portions are diſtinguiſhed, but not deeply, and afterwards ſend out each of them their medulla; which is, by degrees, ſo collected together in rays or branches, meeting in one trunk, that the whole reſembles the figure of little trees. This medulla, collected together into the large crura of the cerebellum, and marked in the inner part with ſerrated cortical lines, interwoven with one another, hath a threefold termination. One part aſcends towards the baſis of the nates, where it joins with the medulla of the brain under the teſtes; but the right and left parts of it are joined to each other by a tranſverſe medullary ſtria behind the nates. From this, ſome diſtinct fibres aſcend outwards, and join themſelves to the tranſverſe ones of the bridge. Between theſe firſt proceſſes of the cerebellum, is ſtretched a medullary lamina, behind the fourth ventricle, ſending forth fibres beyond the proceſs. Another portion deſcends into the ſpinal medulla, and terminates in peculiar nail-like protuberances, which are each anonymous, and have other cortical portions near them. A third portion, which is larger, and ſinuated in the middle, goes tranſverſely downward under the crura of the brain, which it embraces; and by twice intermixing alternately with their tranſverſe medullary fibres (CCCLII.), it is in a great meaſure confounded together with them.

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[97] So called by Sylvius, as the jugum itſelf, under which runs the pons Sylvii.

CCCLV. Thus is produced from the crura of the brain deſcending above thoſe of the cerebellum, and from the medulla of the cerebellum tranſverſely ſurrounding that of the cerebrum, the *pons*, at firſt almoſt oval, but more blunted on both ſides, depreſſed in the middle, and inſcribed on all ſides with tranſverſe fibres. Then the *medulla oblongata*, continuous to the pons, is internally variegated and ſtreaked with a ſubſtance like the cortex, and deſcends of a conical ſhape, inclined to the great foramen in the occiput. This medulla has two pair of tubercles before the pons; the outermoſt of the figure of an olive, and the innermoſt of a pyramidal ſhape, for they leſſen downward like a cone; and theſe are immediately divided by a ſulcus, through which the pia mater enters. But betwixt that medulla and the worm-like proceſs of the cerebellum, is formed a cavity, limited by the four leſſer proceſſes, which as they aſcend or deſcend is at firſt narrower; but above the tubercle (CCCLIV.) it grows broader, and is of a rhomboidal figure: it is called the *fourth ventricle*. It is ſhut in its back-part by the valvula magna, or a medullary velum, uniting the proceſſes going from the cerebellum to the nates and vermis, and tranſverſe ſtria lying under the teſtes, and ſhutting the ventricle

behind,

behind (CCCLIV.) This ventricle has a moderately large ſulcus or furrow, having ſwelled lips on each ſide inſcribed on the medulla oblongata, and anſwering to the canal that is covered by the nates and teſtes, called the *aqueduct* (CCCXLVIII.) In this laſt ventricle, as well as in the foregoing, is lodged the plexus choroides, only leſs in bulk, together with an upper ſulcus called *calamus*. Each of theſe ſulci is continued down along the medulla ſpinalis, both in its anterior and poſterior ſide; more evidently in the former, but leſs ſo in the latter. Tranſverſe fibres are detached in its upper part from the right to the left ſide, both of the medulla oblongata and ſpinalis. But two or three of the tranſverſe ſtreaks that ariſe from the eminences which intercept a ſulcus, are inſerted into the ſoft part of the acouſtic nerve; others go to the eighth pair, and others of the ſame kind aſcend to the crus of the cerebellum.

CCCLVI. All the medulla of the brain and cerebellum goes out from the ſkull, through particular openings, to the parts to which it is deſtined. The ſmaller bundles of this medulla we call *nerves;* but the larger, deſcending through the ſpine, we call the *medulla ſpinalis*, which is a continuation of that called *oblongata* (CCCLV.) But the nerves, which are bundles of the medulla, and very ſoft in their origin, are compoſed of ſtraight parallel fibres in diſtinct threads. Theſe nervous cords, after they have gone forward ſome length, covered with the firm pia mater of a rediſh colour, are afterwards united into a more tough or permanent ſtring; and then, conjoined, divided, and in the neighbourhood of others like themſelves, they haſten through a cellular texture to their proper opening in the dura mater, and thence run down through the intervals of the channels formed by that membrane, till they meet with an opening in the ſkull, out of which they paſs through the membranous funnel of the dura mater. The nerve, having arrived without the ſkull, is commonly ſurrounded by the dura mater, ſo as to become very ſolid and firm. Thus it is in the optic nerve, in the fifth pair, and in others; but in ſome again there does not appear to be any dura mater ſurrounding the nerve, as in the olfactory nerves, in the ſoft portion of the auditory nerve, and the intercoſtal. The nerves now deſcend naked or leſs fenced betwixt the muſcles, detaching their cords or threads of which they are compoſed, and are ſtill made up of the medulla covered by the pia mater. Many ſmall threads of this kind are joined together into larger, by the union of the cellular ſubſtance that ſurrounds them, through which run many ſmall arteries and veins intermixed; and ſometimes fat itſelf is therein lodged. But in general the outer covering, common to the whole nervous bundle, is either derived from the dura mater, or at leaſt is a hard plate of the cellular ſubſtance, wherein all the ſmaller threads are contained and united into one nerve, often reſembling a true membrane.

CCCLVII. It is common to all the nerves of the head to ariſe and paſs out from the lower part of the medulla of the brain or cerebellum[98]. The *olfactory nerve* ariſe with

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[98] The real origin of the nerves of the brain is placed now beyond diſpute, ſince the elegant tables of Santorinus and of the learned Sommering were publiſhed, with which the celebrated Camper agrees in his Tables. which are not yet come out, and with Mayer alſo. Nature herſelf has divided all the nerves in the animal body into three claſſes; the firſt of which contains the nerves, whoſe origin is from the brain, coming through the foramina of the cranium: I ſimply call theſe the nerves of the cranium. The ſecond comprehend the greater number of thoſe ſent from the ſpinal marrow, which I call ſpinal nerves: and the third contains only a few, which are compoſed of others, and might be called mixt, if there was need of a particular name. To this belongs the acceſſorius, which is a true ſpinal one; the great ſympathetic, a very complicated nerve; and the phrenic and ſplanchnic. Nobody will call in queſtion the limits and attributes of the ſpinal nerves ſince the time of the greata natomiſt Baron de Aſch; but it is certain, that the real number of the nerves of the firſt claſs was not determined before the famous Sommering, who firſt devulged the opinion of his maſter. For indeed, if we conſider, without regard to the parts, the riſe, nature, deſcent, and termination of the portio dura of the ſeventh pair, then the proper pair of nerves, we ought to make the eighth there, and to diſtinguiſh it by the name of *communicans faciei.* All which are next in order, belong

with lateral fibres from the interval betwixt the anterior lobe of the brain, but with direct fibres from the medulla of the anterior lobe itſelf. A great part of the *optic nerve* ſprings from the thalami (CCCXLV.), but ſome part likewiſe from the crus of the brain, while the nerves decuſſate through its ſubſtance. The third ariſes from the loweſt crus of the medulla of the brain behind the mammillary bodies. The fourth, which is either ſimple or trifid, ſends a proceſs from the ſide of the cerebellum to the teſtes. The fifth ariſes plainly from the peduncles of the cerebellum itſelf[99]. The ſixth out of a ſulcus (CCCLIV.) deep from the bottom of the pons betwixt that and the medulla oblongata. The ſeventh ariſes with one part ſofter from the medulla oblongata, and by two tranſverſe ſtriæ, from the fourth ventricle itſelf; and with another part harder from that portion of the crus of the cerebellum which lies next the pons[100]. The eighth nerve ariſes from the interval betwixt the olivary and pyramidal bodies or protuberances; and, according to the obſervation of other eminent anatomiſts, from the fourth ventricle likewiſe. The ninth ariſes from the corpora olivaria and pyramidalia. The tenth, by reaſon of its double root, is reckoned a nerve of the neck, going out with an arch, in company with the upper and lower adjacent nerve. There

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long to the medulla oblongata; the firſt pair of which is the gloſſopharyngæus; ſecond, the vagus; third, the lingualis medius, and then begin the pinales, furniſhed with a double root and ganglion; the firſt of which is the celebrated pair of Aſch, denominated the *tenth* by Willis.

[99] By my experiments it conſiſts evidently of a double portion; the minor or anterior, compoſed of from 4 to 6 nervous faſciculi, and ariſing from the upper and high part of the foot-ſtalk; the greater, or poſterior and inferior, made up of 34 to 50 faſciculi, and riſing from the middle line of the foot-ſtalk; a deſcription of which I inſerted in the Gottenburg Commentaris, as well as the famous anatomiſt Sommering.

[100] There are three portions of nerves, which are commonly taken in under the ſeventh pair: *a*, the communicans faciei, or the portio dura, which we may alſo call the ſmall ſympathetic; *b*, a new intermediate portio; *c*, the auditory or acouſtic properly ſo called. They are clearly repreſented by my ingenious pupil Sommering, Tab. 2.

There is, therefore, no nervous branch that ariſes properly from the cerebellum, unleſs it be the fifth: for the anterior nerves, the olfactories, optics, and third nerve, come from the brain only; and all the reſt from thoſe parts where the medulla, both of the brain and cerebellum, is conjoined.

CCCLVIII. The *ſpinal medulla* is a kind of very ſoft medullary rope or appendix to the encephalon, continued down from the medulla oblongata, as low as the ſecond vertebræ of the loins. In the neck its anterior and poſterior ſides are flat, laterally convex, but in the back it is ſquare. It is largeſt where it goes out from the head; from thence it is ſmaller in the top of the neck; in the lower part it is larger; but ſmaller again through almoſt the whole back; thicker in the lower, oval, and conical part of it; and laſtly it ends in tubercles. The pia mater is a proper integument to this part as well as to the brain, ſince it enters the foremoſt fiſſure deeply, and divides the medulla almoſt into two. The cortical ſubſtance which lies within it is obſcure. It has an anterior artery produced in the ſkull, from the branches of the vertebrals. This artery is retrograde, and deſcends through the whole length of the pia mater, perpetually making alternate ſinuous flexures, which form inoſculations about many but not all of the nerves, with branches of the vertebral, intercoſtal, lumbar, and ſacrolumbar arteries; till at laſt, being covered with a peculiar coat from the pia mater, it goes out and diſappears at the coccyx. In like manner the two poſterior arteries, which are leſs, ariſe and are diſtributed from the lower arteries of the cerebellum, and are more ſerpentine, and frequently inoſculated among themſelves. The ſpinal veins deſcend, together with the arteries, from the brain itſelf, ſending out branches in like manner on each ſide, which accompany the nerves like ſo many circular ſinuſes, fixed in the dura mater, and correſponding to the number of the vertebræ; all which ſo communicate one with another, that each has on all ſides a direct conſent both with the uppermoſt and lowermoſt; and, after having ſent out branches that join the vertebral, intercoſtal, and lumbar veins, they unite with thoſe of the ſacrum. The uppermoſt of theſe ſinuſes inoſculates with the anterior occipital ſinuſes (CCCXXXII.)

CCCLIX. But there is another covering, not ſpread with any veſſels, which ſurrounds the ſpinal medulla looſely and at a diſtance, and is pretty firm, of a watery clearneſs, called *arachnoides;* and which being longer than the pia mater, is extended to the bottom of the os ſacrum, where the nerves, only deſcending from the medulla, are collected by it into a faſciculus. But in what manner it goes out, together with the nerves, has not hitherto been deſcribed. Between that membrane and the dura mater there exhales a vapour, which is frequently condenſed into a reddiſh water, and produces a true dropſy.

CCCLX. Laſtly, the *dura mater*, belonging to the ſpinal medulla, and continued from that of the cerebellum, ſurrounding the arachnoides, and from thence deſcending to the bottom of the os ſacrum, being larger at its beginning, at the bottom of the neck, and at the loins, but ſlenderer in the back, and being connected ultimately by many ligaments to the os ſacrum, it at laſt diſappears in a ſlender cone. As the nerves paſs out through this membrane, it gives them an external covering; and directly thickens or ſwells with them into a *ganglion*, or hard, oval, reddiſh-coloured knot. To this hard covering of the dura mater internally adheres a ligament denticulated at the interval of each of the nerves, which ariſes from the ſkull near the courſe or paſſage of the ninth pair of nerves, tying the arachnoides to the dura mater by triangular productions in each of the intervals of the nerves, and betwixt the anterior and poſterior bundles of the ſpinal nerves down to the bottom, and twelfth vertebra of the back. Externally there is a ſort of fat ſurrounds the dura mater, and alſo lines internally the covering of the vertebræ of the ſpine; which by this means are ſo adapted like a tube to the medulla ſpinalis, that the latter is not liable to be compreſſed by the bending of it in any poſition.

CCCLXI. The fibres of the ſpinal medulla, in dropſical ſubjects and in brute animals, appear very diſtinct. Theſe medullary fibres go out from the whole anterior and poſterior ſides of this long appendix; after which, the anterior cords are commonly wrapt up in the pia mater, in which they converge together like rays into a larger faſciculus; to which alſo join ſimilar threads in another bundle from the poſterior faſciculi joining together into one nerve, which, paſſing out through the holes of the dura mater, produces a nerve betwixt each two vertebræ. Theſe vertebræ are about 30 in number. In the neck, numerous radiated nervous fibres compoſe one large and almoſt tranſverſe nerve. In the back they deſcend, in general, of a ſmaller ſize; but ſo that the lower and larger ones are commonly joined cloſe to one another. The large and long lumbar ones join to form the cauda equina. The loweſt nerves of the os ſacrum are the leaſt, the uppermoſt ones large. Many of the dorſal nerves, together with the lumbar ones, and thoſe of the os ſacrum, covered with their proper membrane from the pia mater, accompanied with their arteries, and incloſed in the arachnoides, make up that rope which is called the *cauda equina*.

CCCLXII Thoſe nerves are afterwards diſtributed to all parts of the body in a manner very complex, and not here to be deſcribed. But we muſt not omit to obſerve, that all the ſpinal nerves, except one or two in the neck, have both an anterior and poſterior trunk. This is only ſent to the muſcles. It produces a nervous root; which joining the other adjacent nerves, and having given a ſmall circle that proceeds from the ſixth nerve of the brain and the ſecond branch of the fifth, comes through the pterygoide canal, and forms one of the principal nerves of the human body; which, communicating with almoſt all the other nerves of the whole ſyſtem, ſends out nervous branches to the heart and all the viſcera of the abdomen. The ſame has as many ganglia as roots from the medulla, unleſs where many of them join into one ganglion. It communicates in various places with the crural, brachial, and diaphragmatical nerves, alſo with the par vagum and ninth pair of nerves. The other primary or capital nerve is the eighth or *vague nerve*, ariſing from the brain, and joining itſelf to the intercoſtal in the bottom of the neck, in the thorax, and in the abdomen: this paſſes out of the ſkull in three cords; of which the larger ſends branches to the larynx, gula, lungs, and the cardiac plexus itſelf (XCIX), alſo to the œſophagus, ſtomach, and liver. The third of theſe is the *phrenic nerve*, ariſing from moſt of the lower nerves of the neck and arms; and ſometimes, being increaſed from the root of the ſpinal nerve, it deſcends by the ſide of the pericardium, and inſerts itſelf into the upper face of the diaphragm; but below it receives nerves from the great plexus of the intercoſtal nerve. Laſtly, the *acceſſory nerve*, ariſing by many ſmall roots from the ſix or ſeven uppermoſt poſterior nerves at the neck, and from the medulla oblongata, joins the nerve of the eighth pair going back again into the ſkull, and ſeems, by this means, to make a conſent betwixt that important nerve and the ſpinal medulla. Moreover, the nerves of the limbs have at their origin plexuſes or knots, and are, on account of their length, harder and firmer in their ſubſtance, and much larger, than the great nerves which go to the viſcera: thoſe which go to the hand, ariſe from the four lower nerves of the neck and firſt of the back; but thoſe of the lower extremity from the nerves of the loins and os ſacrum.

CCCLXIV. The nerves divide into branches like the blood-veſſels, but in acute angles, and often in a courſe manifeſtly retrograde, growing gradually ſofter and leſs in bulk, though ſometimes they become thicker as they recede from the brain, till at length their ultimate extremities, which are ſeldom viſible, ſeem to terminate in a pulp, by depoſiting the firm integuments with which they were covered, after the manner which we obſerve in the optic nerve. But the rectilineal courſe of the fibres, continued from the brain itſelf, is ſuch, that it is never broken off by the diviſion or ſplitting of a nerve into ſmaller threads, which only recede from each other by an opening of the cellular ſubſtance that tied them together. This appears from the diſorders, which are determined not to all, but only to ſome ſingle parts by injuries of the brain; as a loſs of the voice, deafneſs, dumbneſs, and palſies of particular muſcles [101]. They are connected in their courſe by the cellular ſubſtance to the adjacent parts, but have hardly any elaſticity; whence they do not fly back after being divided, but only expel, by the contraction of their integuments, the ſoft medulla which they include. But though they are irritated ever ſo much, they are neither contracted, nor are they rendered ſhorter during the motion of the muſcles which they produce. A great many nerves are ſent into the muſcles [102]; many of them go to the ſkin; but fewer to the viſcera, and feweſt of all to the lungs[103]; none at all to the dura and pia mater, arachnoides, tendons, capſules, and ligaments, and laſtly the whole ſecondary membranes. They make frequent inoſculations with each other, or one trunk gives off many branches: and principally from the conjunction of theſe branches the nervous ganglia are formed; i. e. hard nervous tumours, for the moſt part repleniſhed with blood-veſſels, and included in a firm membrane, but of a uſe and ſtructure as yet not certainly known, in which the ſtraight courſe of the nervous fibres is interrupted. The nerves of the ſenſes alone are excepted from theſe ganglia or knots, together with the eighth pair; but they ſeem in a manner eſſential to the phrenic nerves, to the fifth pair, to thoſe of the limbs, to the ſpinal and to the intercoſtal nerves, which laſt are truly ſpinal nerves.

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[101] The want of ſmell, ſight, and hearing, is incurable, if the nerves are compreſſed or deſtroyed by tumours, ſcirrhi, and in particular venereal ulcers, ariſing in that part of the brain where the nerves come out.

[102] More nerves manifeſtly enter the organs of ſenſe than the muſcles.

[103] It is very certain that the lungs are ſupplied with more nerves than the ſpleen, uterus, and other viſcera.

CCCLXV. Thus far we are taught by anatomy concerning the brain and nerves; it now remains only that we explain the phyſiological uſes of theſe parts. Every nerve, therefore, that is irritated by any cauſe, produces a ſharp ſenſe of pain. But we muſt reckon the mind to be changed, when any change happens to the body. It is the medullary part of the nerve which feels the pain. If the nerve was endued with any peculiar ſenſe, that ſenſe periſhes when the nerve is compreſſed or diſſected: the ſenſes of the whole body are loſt by a compreſſion of the brain; and of thoſe parts whoſe nerves originate below the ſeat of preſſure, if you compreſs the ſpinal marrow. If certain parts of the brain are compreſſed from which particular nerves ariſe, then thoſe ſenſes only are loſt which depend on the nerves, as the ſight or hearing. Thoſe parts of the body which receive many nerves, as the eyes and penis, have the moſt acute ſenſation; thoſe have leaſt ſenſibility which receive few nerves, as the viſcera; and thoſe which have no nerves, as the dura mater, tendons, ligaments, ſecundines, broad bones, and cartilages, have no ſenſation.

CCCLXVI. It is therefore evident, that all ſenſation ariſes from the impreſſion of an active ſubſtance on ſome nerve of the human body; and that the ſame is then repreſented to the mind by means of that nerve's connection with the brain. But this ſeems to be falſe, that the mind perceives immediately by means of the ſenſoria and branches of the nerves. For this opinion is refuted, by the pains felt after amputation, the ceſſation of all pain when the nerve is compreſſed, and the deſtruction of the ſenſes by diſeaſes of the brain. And that the effect of the ſenſes is preſerved in the brain, is evident from the loſs of memory which follows when the brain is injured or compreſſed; alſo from the delirium which happens in ſome diſeaſes, and the ſtupor and ſleepineſs which happen in others. We have already obſerved, that the dura mater has no ſenſation.

CCCLXVII. Another office of the nerves is to excite motions, even the moſt violent ones, in the muſcles. When a nerve is irritated, the muſcle to which it goes is immediately convulſed; or if it ſends branches to ſeveral muſcles, they are all convulſed at the ſame time. This happens during the life of the animal, and a little after its death, while all the parts are moiſt. By a great irritation other muſcles are thrown into convulſions, and afterwards the whole body. Nor is it neceſſary that the nerve ſhould be whole; for even when it is cut, an irritation of it will excite ſimilar motions in the muſcles. On the other hand, when a nerve is compreſſed or tied, a palſy follows; for the muſcles which have their nerves from that one lie unmoved, when they are commanded by the will to act. They alſo recover their motion when the compreſſion is removed, provided the nerve has received no hurt.

CCCLXVIII. But the medulla of the brain being vellicated or irritated deeply in its crura, dreadful convulſions enſue throughout the whole; and this without any exception, whatever be the part of the brain ſo affected; nor is there any difference in the brain, cerebellum, or corpus calloſum. The ſame conſequences alſo follow, if the ſpinal medulla be irritated. But if the encephalon itſelf be compreſſed in any part whatever, there follows thence a loſs of ſenſe and motion in ſome part of the body, which muſt be the part whoſe nerves are detached from the affected or compreſſed quarter of the brain. This is clearly evidenced from experiments which have been made on particular parts of the brain diſordered: as from thoſe, for inſtance, in which the origin of the nerves is compreſſed, the voice is loſt; or the motion of one arm or leg, or one ſide of the pharynx, is aboliſhed. But in the injuries of the ſpinal medulla, it is ſtill more evident, that thoſe parts which receive their nerves ariſing from the place injured in the medulla, are either convulſed, if that be irritated, or rendered paralytic, if it be compreſſed. But when any more conſiderable or large portion of the brain ſuffers a compreſſure, either from blood, water, ſcirrhus, an impacted bone, or other mechanical cauſes, the greateſt part, and then the whole, of the body loſes its power of motion; of thoſe organs which obey the will when the malady is in a leſſer degree, and of them all when it is greater; all which diſorders ceaſe upon removing the compreſſing cauſe. Laſtly, if the ſpinal medulla, entering the neck, be injured, death immediately follows; becauſe from thoſe parts principally ariſe almoſt all the nerves of the heart (XCIX.)

CCCLXIX. Theſe things being conſidered, there ſeems to be no doubt, but the cauſe of all motion in the human body ariſes from the brain with its annexed cerebellum and ſpinal marrow; and that it thence proceeds through the nerves to all the muſcular parts of the body. The cauſe, therefore, of this motion cannot reſide in the parts themſelves, becauſe otherwiſe the moving cauſe would continue to act after being ſeparated from the brain; nor would it be increaſed by irritating the brain, or weakened by a compreſſure of it.

CCCLXX. Whether or not is there in the brain any principal part, in which reſides the origin of all motion, the end of all the ſenſations, and where the ſoul has its ſeat? Whether is this proved by the frequent obſervation, that the ſenſes are ſometimes entire, and that motion likewiſe remains, though the brain is grievouſly hurt? Is it in the corpus calloſum? Or is this ſhown by the greater fatality of wounds or diſeaſes in the corpus calloſum? Is this body ſufficiently connected with the nerves? Are there any experiments which deduce from thence the fifth, ſeventh, and other nerves? Doth not the ſame or even greater mortality of wounds in the medulla ſpinalis prove the ſame thing? Yet this is not the ſeat of the ſoul, ſeeing, though it is compreſſed or even deſtroyed, the perſon will ſurvive a long time with the perfect uſe of all his ſenſes. Nay, this opinion is oppoſed by very many facts: birds have no corpus calloſum;

ſum; and wounds in that body are not in the leaſt more mortal than thoſe in other parts of the brain, as appears from undoubted experiments.

CCCLXXI. But the power of the cerebellum is not greater in exciting the vital motions, nor are the vital and animal functions diſtinct; nor does the cerebellum produce the nerves of the heart and of other vital organs, and the brain thoſe which go to the organs of ſenſe and voluntary motion. From the cerebellum the fifth nerve is moſt evidently produced; but that goes to the tongue, pterygoide, buccinator, temporal, and frontal muſcles, the lap of the ear, the eye, the noſtrils; all which are parts either moved by the will, or deſtined for ſenſe. Again, the ſame nerve, like the eighth, ſends vital branches to the heart and lungs, animal and voluntary ones to the larynx, and ſenſitive ones to the ſtomach. Again, it is not even true, that diſorders of the cerebellum bring on ſo certain and ſpeedy death. For certain experiments, even of our own making, ſhow that it has borne wounds and ſcirrhi, without taking away life; nor is it much different from the brain, only that it is ſofter and more tender; and laſtly, we have known, and that not very rarely, wounds of the cerebellum cured. The power, however, of this part, in exciting convulſions, is ſomewhat greater.

CCCLXXII. Concerning the ſeat of the ſoul, we muſt inquire experimentally. In the firſt place, it muſt be in the head, and not in the ſpinal marrow. For though this is obſtructed, the conſtancy of the mind remains the ſame. Again, it appears, from the experiment of convulſions ariſing, when the inmoſt parts of the brain are irritated, that it lies not in the cortex, but in the medulla; and, by a probable conjecture, in the crura of the medulla, the corpora ſtriata, thalami, pons, medulla oblongata, and cerebellum. And again, by another not abſurd conjecture, where the origin of every nerve lies, as the firſt origins of all the nerves taken together make up the ſenſorium commune. Are the ſenſations of the mind repreſented there, or do the voluntary and neceſſary motions ariſe in that place? This ſeems very probable. For it does not ſeem poſſible, that the origin of motion can lie below that of the nerve; for although it ſhould be aſſumed gratis, that ſome part of the nerve is immoveable, or inſenſible, yet that is altogether ſimilar to the remainder of the nerve. Nor can the origin of motion (CCCLXIX.) depend upon the arteries, which have neither the faculty of ſenſation nor that of voluntary motion. It therefore follows, that the ſeat of the mind muſt be where the nerve firſt begins its formation or origin.

CCCLXXIII. We come now to explain the manner in which the nerves become the organs of ſenſe or motion; which, as it lies hid in the ultimate elementary fabric of the medullary fibres, ſeems to be placed above the reach both of ſenſe and reaſon; but we ſhall, notwithſtanding, endeavour to make this as plain as experiments will enable us. And firſt, it is demonſtrated, that the ſenſation does not come through the membranes from the ſentient organ to the brain, nor that motion is ſent through the coverings from the brain into the muſcle. For the brain itſelf lies deeper than theſe membranes, and receives the impreſſions of ſenſe, and when hurt throws the muſcles into convulſions. Moreover, it is certain, that the nerves ariſe from the medulla of the brain; the truth of which is manifeſt to the eye in all the nerves of the brain, more eſpecially in the olfactory, optic, fourth and ſeventh pair of nerves, which continue their medullary fabric a long way before they put on the covering of the pia mater.

CCCLXXIV. We muſt, therefore, next inquire into this medulla, what it is. It is a very ſoft pulp, harder in inſects and fooliſh animals; but every where ſimilar to itſelf. It affects, however, to be formed into fibres or parallel threads, lying upon one another lengthwiſe. That the compoſition of it is fibrous, appears from innumerable arguments; more eſpecially to the eye in the corpus calloſum, in the ſtriatum, and thalami of the optic nerves; but ſtill more evidently in the brains of fiſh, and eſpecially in their thalami optici[104]. Again, that the fibres of the brain are continuous with thoſe of the nerves, ſo as to form one extended and open continuation, appears, by obſervation, very evidently in the ſeventh, fourth, and fifth pair of nerves. There is a great deal of oil in the medulla, upwards of a tenth part of its whole weight.

CCCLXXV. But here a controverſy begins concerning the nature of this fibril, which with others of the like kind compoſes the ſubſtance of the medulla and of the nerves. That this is a mere ſolid thread, and only watered by a vapour exhaling into the cellular fabric which ſurrounds the nervous fibres, has been aſſerted by many of the moderns; but that, when it is ſtruck by a ſenſible body, a vibration is excited, which is then conveyed to the brain.

CCCLXXVI. But the phenomena of wounded nerves will not allow us to imagine the nervous fibres to be ſolid. For if an irritated nerve is ſhaken, (and that happens after the manner of an elaſtic cord, which trembles when it is taken hold of,) the nerve ought to be made of hard fibres, and tied by their extremities to hard bodies: they ought alſo to be tenſe; for neither ſoft cords, nor ſuch as are not tenſe, or ſuch as are not well faſtened, are ever obſerved to tremulate. But all the nerves, at their origin, are medullary, and very ſoft, and exceedingly far from any kind of tenſion: where they paſs through channels, where they are well guarded, they retain the ſame ſoft texture, and are not covered with membranes, as in the intercoſtal nerves and the ſecond nerves of the fifth pair: ſome alſo are ſoft throughout their whole length, whatever ſize they may be of; for example, the ſoft olfactory and acouſtic nerves, from which we would moſt readily expect a tremor, as in the caſe of ſound. Again, though the nerves are hard,

they

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[104] In no part of the brain does the fibrous nature of the medulla more evidently appear than in the fornix, immerſed in nitrous acid for ſome continued time; for then I could divide it into the moſt ſubtile fibres.

they are ſoftened in the viſcera, muſcles, and ſenſoria, before they exert their operations. Therefore, the nervous fibres cannot poſſibly tremulate in an elaſtic manner, neither at their origin, nor where they are tenſe. But the ſame, even in the proper and moſt favourable caſes, cannot tremulate; becauſe, through their whole length, they are firmly tied to the ſolid parts by means of the cellular fabric; for example, the nerves of the heart are tied to the great arteries, and to the pericardium. Finally, that the nerves are deſtitute of all elaſticity, is demonſtrated by experiments, in which the nerves cut in two neither ſhorten nor draw back their divided ends to the ſolid parts; but are rather more elongated by their laxity, and expel their contained medulla in form of a protuberance. Again, the extreme ſoftneſs of the medulla in the brain, with all the phenomena of pain and convulſion, leave no room to ſuſpect any ſort of tenſion concerned in the effects or operations produced by the nerves.

CCCLXXVII. Add to this, that the force of an irritated nerve is never propagated upward, ſo as to convulſe the muſcles that are ſeated above the place of irritation. This is a conſequence altogether diſagreeing with elaſtacity; for an elaſtic cord propagates its tremors every way, from the point of percuſſion to both extremities. But if neither the phenomena of ſenſe nor motion can be explained from the nature of elaſticity, the only probable ſuppoſition that remains is, that there is a liquor ſent through the brain, which, deſcending from thence through the nerves, flows out to all the extreme parts of the body; the motion of which liquor, quickenened by irritation, operates only according to the direction in which it flows through the nerve; ſo that convulſions cannot thereby aſcend upwards, becauſe of the reſiſtance made by the freſh afflux of the fluid from the brain. But the ſame liquid being put in motion in an organ of ſenſe, can carry that ſenſation upwards to the brain; ſeeing it is reſiſted by no ſenſitive torrent coming from the brain in a contrary direction.

CCCLXXVIII. It is therefore probable, that the nervous fibres, and the medullary ones of the brain, which have the ſame nature, are hollow. Nor is the objection which ariſes from the ſmallneſs of theſe tubes, not viſible by any microſcope, of any force againſt the propoſed arguments; to which add the abſence of a ſwelling in a tied nerve, which, in reality, is not ſufficiently true; with other arguments of the like kind, which indeed ſhow the weakneſs of the ſenſes, but have not any validity againſt the real exiſtence of a juice or ſpirit in the nerves. If they are tubes, it is very probable that they have their humours from the arteries of the brain.

CCCLXXIX. But concerning the nature of this nervous liquid, there are many doubts. Many of the moderns will have it to be extremely elaſtic, of an etherial or of an electrical matter; but the more reaſonable part make it to be incompreſſible and watery, but of a lymphatic or albuminous nature. Indeed it is not to be denied, that we have many arguments againſt admitting either of theſe opinions. An electrical matter is, indeed, very powerful, and fit for motion; but then it is not confinable within the nerves, ſince it penetrates throughout the whole animal to which it is communicated, exerting its force upon the fleſh and fat, as well as upon the nerves. But, in a living animal, the nerves only, or ſuch parts as have nerves running through them, are affected by irritation; and, therefore, this liquid muſt be of a nature that will make it flow through, and be contained within, the ſmall pipes of the nerves. And a ligature on the nerve takes away ſenſe and motion, but cannot ſtop the motion of a torrent of electrical matter [105].

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[105] There is certainly no phyſiological diſpute, in which, without regard to the parts, a more difficult deciſion can be offered, than that important queſtion, How do the nerves act in the bodies of animals? The doctrine of the nervous fluid, or animal ſpirits, is confirmed by many arguments drawn from anatomy; but is fully refuted by as many, if not more, of a ſimilar nature. But ocular demonſtration of

CCCLXXX. A watery and albuminous nature is common to moſt of the juices in the human body, and may be therefore readily granted to the juice of the nerves; like the water which exhales into the ventricles of the brain from the ſame veſſels; alſo, from the example of a gelatinous or lymphatic juice, which flows out in cutting through the brain in fiſh, and the nerves of larger animals; to which add, the tumour which ariſes in tied nerves. But are theſe properties ſufficient to explain the wonderful force of convulſed nerves, obſervable in the diſſections of living animals, and even in the leſſer inſects, with the great ſtrength of mad and hyſterical people? Whether or no is not this difficulty ſomewhat leſſened from the hydroſtatical experiments of attraction in ſmall tubes; which although it may explain the ſtrength and motion, is nevertheleſs inconſiſtent with the celerity?

CCCLXXXI. The nervous liquor then, which is the inſtrument of ſenſe and motion, muſt be exceedingly moveable, ſo as to carry the impreſſions of ſenſe, or commands of the will, to the places of their deſtination, without any remarkable delay: nor can it receive its motions only from the heart. Moreover, it is very thin and inviſible, and deſtitute of all taſte and ſmell; yet reparable from the aliments. It is carefully to be diſtinguiſhed from that viſible, viſcid liquor exhaling from the veſſels in the intervals between the nervous cords.

CCCLXXXII. That this liquor moves through tubes rather

of the nerves proves, that ſuch a fluid under the name, and ſenſe, which determines fluids in our bodies, moving in canals and hollow fiſtulæ, does not exiſt. However, it is therefore not improbable, that that ſubſtance, which produces the wonderful phenomena in the nerve, is one of the claſs of the more ſubtile fluids of nature. I pretend not to give it a name. Since 1766, I have been inclined to think, that it perhaps reſembles the electric and magnetical fluids; ſince which time, long before Miſmer, I publicly taught the power of magnetiſm upon our body. For this reaſon the nervous principle has been in note 67 numbered in the third claſs of fluids. We may expect that this obſcurity will be greatly removed by the very celebrated anatomiſts Drs Monro and Prochaſka, who have extended and directed their ſtudy to the phyſiology of the nerves.

rather than through a ſpongy ſolid, we are perſuaded from its celerity, and the analogy of the whole body; of which all the liquids, the fat excepted, run through their proper veſſels.

CCCLXXXIII. Therefore, upon the whole, it ſeems to be certain, that, from the veſſels of the cortex, a liquor is ſeparated into the hollow pipies of the medulla, which are continued with the ſmall tubes of the nerves, even to their ſoft pulpy extremities, ſo as to be the cauſe both of ſenſe and motion. But there will be a twofold motion in that humour; the one ſlow and conſtant, from the heart; the other not continual, but exceedingly ſwift, which is excited either by ſenſe or any other cauſe of motion ariſing in the brain.

CCCLXXXIV. The ſame nerves moſt evidently preſide over both ſenſe and motion; as we cannot admit a diſtinction between the two ſyſtems of motory and ſenſitive nerves. If ſenſe ſometimes remains after motion is deſtroyed, this ſeems to be becauſe much more ſtrength is required for the latter. Dying people hear and ſee, when they are incapable of motion.

CCCLXXXV. If it be aſked, What becomes of this nervous juice, which cannot but be ſeparated and diſtributed in great abundance, from ſo large a quantity of blood paſſing the brain very ſwiftly, in compariſon of the ſlower moving blood, from whence the milk is ſeparated in the breaſt, and the urine in the leſſer renal artery, or by a compariſon with the meſenteric artery? it may be anſwered, It exhales probably through the cutaneous nerves; the laſſitude both with reſpect to ſenſe and motion, which may be overcome by ſpirituous medicines, ſhows that this liquid may be both loſt and repaired. Many have judged, that it alſo exhales into the various cavities of the body; as that of the ſtomach and inteſtines. We may expect ſome part of it to be reſorbed, that the nobleſt humour of the body may not be too quickly diſſipated. That it nouriſhes the body, is incredible: It is too moveable to expect adheſion from it: that is the office of a ſlow and viſcid humour.

CCCLXXXVI. But then, what is the deſign of ſo many protuberances in the brain? what are the particular uſes of the ventricles, nates, and teſtes; with the diſtinction of the brain from the cerebellum; and the communication betwixt one ſide of the brain, cerebellum, and ſpinal medulla, with their oppoſite ſides, by ſo many tranſverſe bundles of fibres[106]?

CCCLXXXVII. The ventricles ſeem to be made of neceſſary conſequence, and towards the greater uſe and diſtinction of the parts. And that the corpora ſtriata or thalami might keep their medullary parts from cohering one to another, it was neceſſary for a vapour to be poured betwixt them; and the ſame is true with regard to the brain and cerebellum. Perhaps, likewiſe, the neceſſity of adminiſtring a degree of warmth to the cloſe medulla of the brain, may be one reaſon for theſe cavities, by which the arteries enter, and are diſtributed in great numbers. Perhaps alſo it was proper, that, in the inmoſt parts of the brain, ſmall veſſels only, without any large ones, ſhould enter. We may alſo ſuſpect, that the ſoftneſs of the fibres of the brain requires ſhortneſs in order to ſuſtain their own weight.

CCCLXXXVIII. The uſes of moſt of the protuberances we are not acqainted with, but have them yet to learn from diſeaſes, and from anatomical experiments made on animals having a brain like that of mankind. But, in theſe reſpects, we have little hopes of ſucceſs, in parts that are ſo ſmall, ſo deeply, and ſo difficultly ſituated, and hardly ever to be approached but by a wound ſoon fatal. Whether theſe parts are ſo many diſtinct provinces in which our ideas are ſtored up, and whether this be confirmed by the protuberant thalami of the optic nerve, are indeed queſtions. But then moſt of theſe protuberances ſend out no nerves at all.

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[106] Theſe queſtions will be anſwered, when the brains of ſeveral animals ſhall have been compared with their functions. The learned Sommering has already ſaid much about this ſubject, and Camper likewiſe in fiſhes.

CCCLXXXIX. As to the internal communication of one part with the other by ſtriæ or ducts; that ſeems to conduce to the advantage of motion, and probably of ſenſe likewiſe. Some of theſe communications join the brain with the cerebellum; others join the ſpinal medulla with the nerves of the brain itſelf, as in the acceſſory nerve; and moſt of them join the right and left parts together, as in the anterior commiſſure (CCCXLV.), and in the two poſterior (CCCL.), in that of the corpus calloſum (CCCXLIII.), in the ſtriæ betwixt a proceſs of the cerebellum and teſtes (CCCLIV.); to which add the medullary croſs-bars in the medulla oblongata and ſpinalis (CCCLV.) For from this ſtructure, it ſeems manifeſtly to follow, as well as from numberleſs experiments and obſervations, that when the right ſide of the brain is injured, all the nerves which, on the contrary, belong to the left ſide of the body, become diſeaſed or paralytic, and the reverſe. Moreover, by this contrivance, nature ſeems to have provided, that, in whatever part of the brain any injury may happen, the nerve that ariſes from thence is, by this means, not always deprived of its uſe. For if the ſaid nerve receives its fibres by communicating bundles, as well from the oppoſite as from its own hemiſphere of the brain, its office may in ſome meaſure be continued entire by the fibres which it receives from the oppoſite ſide, even after thoſe of its own ſide are deſtroyed. Accordingly we have numberleſs inſtances of wounds, and with a conſiderable loſs of ſuſtance from the brain, which yet have not been followed with injury to any nerve, or to any of the mental faculties. Many other leſs inequalities, ſtripes, protuberances, and nerve-like impreſſions, appear in the brain from mechanical neceſſity, with the pulſation of the veſſels, and the preſſure or figure of the continuous incumbent parts.

CCCXC. We have before declared, that the nerves are the organs of ſenſe and motion: we ſhall therefore proceed firſt to explain that motion before we deſcribe the organs of ſenſe; becauſe it is more ſimple, uniform, and perpetually exerciſed, even in the fœtus, before any of the ſenſes.

CHAP. XII.

Of Muscular Motion.

CCCXCI. MOTION in the human body is not performed by one individual organ. In every animal and vegetable fibre, alſo in hair, feathers, membranes, the cellular texture, and in the humid muſcular fibre; in ſhort, in animal and vegetable gluten; there is a contractile power, which both reſiſts the lengthening out of its ſubſtance, and, when the extending power is taken away, reſtores the fibre to its former ſize; nor does this power ever ceaſe endeavouring to bring the elementary particles into the cloſeſt contact the mechaniſm of the part can admit. After death, even for many days, it does the ſame; ſo that fibres of a divided muſcle contract towards each extremity, leaving a wide gap in the middle. An artery, when cut, likewiſe contracts itſelf in length.

CCCXCII. I call this force *dead*, becauſe it continues to be efficacious after death, and ſo is different from the powers of life. In the living animal indeed it is ſomewhat briſker: for, both from cold and fear, the ſkin is moved, ſo that it grows harder, and has its papillæ erected, and along with this hardneſs contracts itſelf in length. Again, the cellular fibres are animated with this perpetual niſus to ſhorten themſelves, and always tend to their own contraction. Hence, when the ſkin or any other membrane is extended, as ſoon as the cauſe of extenſion is taken off, it returns by a gentle effort to its former ſhortneſs. But it even ſomewhat reſiſts the attempt to perpetual diſtenſion; and by a gentle but continual acceſſion of its own elements, propels the contained fat or water, or other bodies accidentally introduced. The ſame power alſo ſeems to limit the excretion of vapour; for the fibres and plates of the cellular texture being preternaturally relaxed, an immenſe quantity either of fat or of watery humour is depoſited in that texture. And this debility ſeems to be the principal cauſe of a true dropſy. The ſame cauſe being always efficacious, and at work in the heart, joints, and every where throughout the body of the embryo, brings into nearer contact the arteries, auricles, and ventricles; produces flexures; and contracts the heart, when in a manner diſſolved into a cone. The ſame, by an unknown or hidden power, ſeems to form the ſhape of moſt parts of the human body; and while it expels the gluten received into the cells, brings the terreſtrial particles nearer to one another, and gives the proper ſolidity, curvature, and ſituation, to the different parts.

CCCXCIII. It is the nature of this power to act continually by a gentle but uninterrupted effort. It is common for it alſo to be excited by poiſons, in every membrane, fibre, and cellular texture; but never by cutting or puncturing with an iron inſtrument. Theſe are the known properties of the red muſcular fibre. The ſtructure of this fibre, then, it is now neceſſary for us to conſider.

CCCXCIV. By the name of *muſcular fibres* in the human body, we call bundles of reddiſh-coloured threads, which perform all the motions of which we are ſenſible. When many of theſe fibres are collected together, and appear more evidently red, they are called *a muſcle*. The extreme ſimplicity of the fabric in theſe parts has been the cauſe of the obſcurity that prevails in underſtanding how a ſmall, ſoft, fleſhy portion, can produce ſuch ſtrong and ample motions as we ſee in man, but more eſpecially in the cruſtaceous inſects.

CCCXCV. In every muſcle we meet with long ſoft threads or *fibres*, ſomewhat elaſtic or extenſible, and almoſt conſtantly diſpoſed parallel with each other; and theſe, being ſurrounded with a good deal of cellular ſubſtance, are by that faſtened together into little bundles.

dles. Thoſe bundles, called *lacertuli*, are again tied together into larger bundles, by a more looſe cellular network, which contains ſome fat; and betwixt theſe we conſtantly perceive membranous partitions and ſtripes of the cellular ſubſtance removing them farther from each other, till at laſt a number of them combined together in a poſture either parallel or inclined[107], are ſurrounded with a more thin and denſe cellular membrane, continuous with that of their partitions; and this being again ſurrounded by a thicker plate of the cellular ſubſtance, externally parts the whole from the adjacent fleſh, and gives it the denomination of a *ſingle* or *entire muſcle*. In every one of theſe threads there appears a leſſer ſeries of filaments, which, by oblique extremities, are cemented to others of the ſame kind, forming together a larger fibre.

CCCXCVI. The generality of the muſcles, but more eſpecially thoſe which are inſerted into the bones, and ſuch as are preſſed ſtrongly by other fleſhy incumbent parts, do not conſiſt of fibres altogether of one kind. For the fleſhy fibres (CCCXCV.) being collected together, cauſe the muſcle to be thicker in the middle, which is called its *belly*: and the ſame fibres degenerating by degrees obliquely at each end of the muſcle into a more ſlender, hard, and ſhining ſubſtance of a ſilver colour, in which meeting cloſer together, the cellular ſubſtance interpoſed is thinner, ſhorter, and painted with fewer veſſels; they then become indolent and difficultly irritable, and receive the denomination of a *tendon*, by being collected together into a round ſlender bundle; or elſe, if it expands into a broad flat ſurface, it is called an *aponeuroſis*. The cellular texture which covers the whole tendon is called its *vagina* or ſheath, and reſembles the coat of a muſcle. For that the fleſhy fibres truly change into ſuch as are tendinous, is evident from comparing a fœtus (in which there are very

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[107] Swammerdam, Lyonet and Roeſel, have elegantly painted this ſtructure in frogs and palmers, which Leewenhoeck, Cowper, Muyſs, and Proſchaſka have ſhown in man.

few tendons) with a child of ſome years growth, in which there are many more; and both with an adult or old perſon, in which are the greateſt number[108]. Muſcles, which are not inſerted into any of the bones, have commonly no tendons, as the ſphincters and muſcular membranes of the viſcera and veſſels. But thoſe commonly end in long tendons, which are required to paſs round the joints and heads of the bones, to be inſerted in thoſe extremities which are more moveable. In a fœtus the muſcles are evidently inſerted into the perioſteum only; but in adults, where the perioſteum is more cloſely joined with the bone itſelf, the tendons, being confuſed with the perioſteum, paſs together with that even into the foveoli of the bone.

CCCXCVII. The tendinous fibres indeed often lie in a ſtraight line with the fleſhy ones, and are as it were a continuation of them. But it is not at all rare for the fleſhy fibres to be obliquely inclined to the tendon, and to adhere to it, as the tendon itſelf grows thicker in its progreſs by continually receiving new fibres. This is called *a tendinous muſcle.* Other tendons lie in the middle betwixt two plates of fibres, forming an obtuſe angle with one another, at irregular diſtances, in their deſcent. There are inſtances of numerous tendons pennated in different places formed into one muſcle. There are alſo other methods by which the tendinous fibres are joined with the fleſhy ones.

CCCXCVIII. Within the cellular tunic, that ſurrounds the fibres, the arteries and veins are ſubdivided into networks, which commonly form right angles, run in company, and moſtly contiguous with each other; and from the ſmaller of theſe veſſels a vapour is exhaled into the thinner cellular ſubſtance, as the fat is alſo transfuſed into the thicker cellular ſubſtance; from whence again they are both abſorbed. The lympthatic veſſels, which run be-

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[108] Many tendons are found in a fœtus, which could not aſſume this nature by muſcular action; as the tendo-Achillis, aponeuroſis plantaris, centrum diaphragmatis, &c. Read the like opinion in Moſcate, *Atti di Siena*, Vol. IV.

betwixt the muſcles of the tongue, with thoſe of the neck, face, and limbs, are difficultly demonſtrated[109]. But there are alſo nerves more numerous than in other parts, diſtributed together with the blood-veſſels throughout the cellular fabric of the muſcle; which nerves, however, depoſite their harder covering, and become ſoft, and diſappear before they can be traced to their ultimate extremities. Thoſe enter the muſcle in many parts, without keeping to the ſame place or ſituation. In the tendons they cannot be demonſtrated. Nor are there any nervous fibres inveſting the muſcular bundles or portions, ſo as to conſtringe them; for they, who have given ſuch a deſcription, have ſeen nothing but the cellular ſubſtance.

CCCXCIX. The fabric of the leaſt fibre, which is as the element of a muſcle, being inveſtigated by the microſcope in man and other animals, has always appeared ſimilar to the fabric of the larger fibres; nor do they yield any other appearance, upon which we can rely, than that of the leaſt threads joined one to the other by the intermediate cellular ſubſtance. There is, therefore, no foundation here for a ſeries of veſicles, nor for a chain of rhombs. It may be aſked, whether theſe fibres are hollow, whether they are continued with the ar-

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[109] The lymphatic veſſels, even of the joints, are now to be reckoned among the conſtant veſſels. I have obſerved a broad net-work running from the carpus and palm of the hand, in the inſide of the arm, in the duct of the veins following the radius and ulna, towards the bend of the fore-arm, in two trunks, joined by various intermediate rami; into which net-work run ſome branches from the outſide of the cubit and arm: they run in a manifold net-work upon the bend of the fore-arm and inſide of the humerus, till by two or three trunks they arrive at the axillary glands, and mix with the ſubclavian plexus. In the inferior extremity, I could render viſible ſeveral of theſe lymphatic veſſels, in three or four trunks upon the leg, and one on the inſide of the foot, going to the ham; then in a few trunks, the number various, they run up from the net-work of the ham, around the inſide of the thigh, in the duct of the vena ſaphena, and are loſt in the inguinal plexus and glands there ſituated; and at laſt a greater plexus enters the abdomen along with the crural veſſels. The ſame veſſels have been ſeen by Hewſon almoſt in a ſimilar diſpoſition.

arteries, or whether the difference betwixt muſcular and tendinous fibres lies in the latter being rendered more denſe and beat cloſer together by an expulſion of the fluids? That theſe are not probable, appears from the minuteneſs of the fibres, which are found leſs than the red-blood globules, and from the whiteneſs of a muſcle after the blood is waſhed out of it; to which add the phyſiological reaſons following, (CCCCXI.) And, in general, more ſtrength may be expected from a ſolid fibre.

CCCC. A muſcle therefore is endowed at leaſt with a threefold force[110]. Firſt, the dead one, in common to it with other animal fibres. Another, which we have called the *vis inſita*, and which has different phenomena from the former. For it is more proper to life, and the firſt hours after death, and diſappears much ſooner than the dead one. Again, in moſt caſes, it acts by alternate oſcillations; ſo that, being driven hither and thither, it ſometimes contracts the muſcle towards the middle: ſometimes again it extends the muſcle from the middle towards the extremities, and ſometimes alſo it has a reiterated motion. Moreover, it is manifeſtly quicker, and performs the greateſt motions; the dead force, only ſuch as are ſmall and not eaſily obſerved. It is excited both by the pricking of an iron inſtrument, and in the hollow muſcles by inflated air, by water, and every kind of acrimony, but moſt powerfully of all by a torrent of electrical matter. Laſtly, it is proper to the muſ-

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[110] Theſe three noted claſſes of animal powers, elaſticity, irritability, and ſenſibility, have been and are yet too much confounded, although it is no difficult taſk to diſtinguiſh theſe affections of the fibres from one another. The force and nature of elaſticity, poſſeſſed by the fibres, which, only in different degrees, pervades all parts without exception, was fully known to Bellini, Baglivi, Stahl, Pacchioni, Juncker, &c. This power, known to Stahl's followers under the appellation of *tone*, has no ſimilarity to irritability, ſenſibility, and vital power, ſo called: it does, however, either alone perform the actions of the animal and vegetable body, or adds ſtrength and vigour to them; the former is manifeſt in the motion of the ribs and cartilages, and the latter in the conſtriction of the uterus, veſſels, and membranes. It by no means obeys the laws of life alone, but may endure long after death; it is not deſtroyed completely but by putrefaction alone. During life it is diminiſhed by various cauſes, and again reſtored by ſeveral remedies. Irritability, which Haller thought exiſted in the fibres of the muſcles alone, in name indeed but not in reality, and which was known to Gliſſon, is a new genus of animal power; nor does the word ενορμουν of Hippocrates, ſignify the ſame thing. It is almoſt proved, from the experiment of Lups, Haller, Fontana, Hoffman, and ſeveral others, that it is different from elaſticity in its riſe, duration, ſeat, cauſes, effect, and phenomena. I ſhall add a few remarks: 1. It is moſt powerful in the muſcular fibres of the whole body, but not equally diſperſed through all; more powerful in the heart, muſcles of reſpiration, and inteſtines; becomes gradually weaker among the voluntary muſcles, and perhaps, in a trivial degree, in the veſſels, membranes; but always ſome however exiſts, as appears from the doubts offered by Whyte, De Haen, Van Doeveren, &c. to which Haller in part, and alſo the learned Cigna, have anſwered. 2. The phenomena of irritability and the irritation, themſelves, by which thoſe are produced, are, not always the ſame: For in ſome it advances in a regular tract, that

that almoſt from any irritation you will always obſerve a manifeſt irritability: this is almoſt the caſe in all the muſcles. In many other parts you ſee the greateſt inconſtancy and a very irregular effect, as it will be one thing one day, another thing another day, now increaſed, now diminiſhed, one time yield to, another time reſiſt, the irritation: all which is evident in the ſkin, viſcera, veſſels, and iris. 3. The learned pathologiſts Eller, Tiſſot, Gerhard, have long ago acknowledged the very great riſe of the doctrine of irritability. It would be of much importance to know well the remedies, whether they be medicines, or remedies from diet or otherwiſe, which particularly conduce to excite irritability if it is languid, or to diminiſh it if it is too great. Opium, and the other narcotics, camphor, Spaniſh flies, acrid poiſons, bark, the electric ſhock, ſhow a clear influx of animal ſpirits in the production of irritability. 4. That it is different from the faculty of feeling, and therefore by no means to depend upon the nerves, appears partly from other reaſons, partly from the irritability of vegetables. Though I even wiſh to take into account ſome phenomena of the dionæa muſcipula, according to Ellis's obſervations, or of the ſenſitive plant or certain antheræ, I would be averſe to compare this contractile power of ſome parts of vegetables with irritability; for what makes the particular character of irritability, the internal tremor of the conſtituent parts, is wanting in all vegetables; we ſee contraction and motion alone, which are alſo obſervable in other elaſtic bodies, where we ſuppoſe no irritability to exiſt. The power of the nerves over irritability, the direction of the ſoul over muſcular motion, although they render it very probable, I, however, refer it to irritations alone. The faculty of feel-muſcular fibre, and is found in no other part of the human body with the qualities abovementioned. But we muſt give a more particular explication of its phenomena.

CCCCI. It is natural to every muſcle to ſhorten itſelf, by drawing the extremities towards its belly or middle. But to diſcover the moving power of a muſcle from the fabric which we have deſcribed, it will be of uſe to conſider the appearances obſervable in the muſcular contraction. Every muſcle then becomes ſhorter and broader in its action. But this contraction of its length is various; in ſome more, in others leſs; and is very conſiderable, for example, in ſome of the ſphincters, inſomuch that they appear to be contracted more than one third of their extent, though this computation be taken from an erroneous hypotheſis.

CCCCII. The inteſtines are exceedingly tenacious of their vis inſita, as they continue to contract themſelves long after they are taken out of the body, and even after they are cold. The heart is even more tenacious than theſe, if you conſider all things; as is moſt evident in a young chicken, and in cold animals. Different

feeling, depending ſolely upon the nerves, although it has been regarded as one and the ſame thing with irritability, has been more ſtrongly oppoſed by Haller's opponents, De Haen, Whyte, Le Cat, Gerhard, &c. than irritability itſelf. But that ſenſibility of parts is to be referred both to the various quantity of the nerves, their ſituation and condition, according to Haller's and Caſtell's experiments, and to the various violence of irritation and nature of the irritating or offending body, ſo that they may be at times more or leſs painful; and at others, as Haller thinks, they may be altogether inſenſible. I ſhall not repeat what has often been objected to, that a greater pain having preceded, abſorbs a leſs pain following; as we do not feel the taſte of a drop of wine if we have taken a very ſmall quantity of rectified alcohol upon the tongue a little before. It cannot however be denied, that in inflammatory diſeaſes, affections of the mind, and other cauſes, it may happen, that hurt parts may now feel, which, under any other condition, may ſeem to be inſenſible. The *vital power* of certain learned men of later times, as Vanden Bos, Bikker, Gaubius, Albinus, &c. rather ſeems compounded of all the animal powers comprehended together; which opinion, except in ſome minutiæ, the great Boerhaave and Simpſon have more exactly adapted.

muſcles are beſt excited into action by different ſtimuli; as the bladder by urine, the heart by the blood, and the inteſtines by air. Though the nerves are removed, or the connection, made by them between the muſcles and the brain, cut off, the muſcles loſe but little of their irritable nature. It appears alſo from the example of polypi and other inſects, that the ſame irritable diſpoſition extends very widely through the animal fibres. Theſe creatures have neither brain nor nerves, yet are exceedingly impatient of ſtimulus. Laſtly, we may gather this from the affinity of plants: of which very many flowers and leaves open or contract according to the various degrees of heat and cold, ſome even very quickly: ſo that they are nothing inferior in this reſpect to animals. Neither does this depend upon weight, attraction, or elaſticity, ſeeing it is ſeated in a ſoft fibre, and vaniſhes when the ſame grows hard.

CCCCIII. But that the cauſe of motion is conveyed through the nerves into the muſcles, is certain from the experiments before mentioned (CCCLXVII. et ſeq.) For the nerve alone has feeling; this alone carries the commands of the ſoul; and of theſe commands there is neither intimation nor perception in that part, whoſe nerve is either tied or cut, or which has no nerve. Moreover, on irritating the nerve or ſpinal marrow, even in a dead animal, the muſcle or muſcles which have nervous branches from thoſe parts are moſt vehemently convulſed. When the nerve of any muſcle is cut or tied, or the baſis of the ſpinal marrow compreſſed, or that part of the brain from whence the nerve has its origin, the muſcle becomes paralytic, and languiſhes, and cannot by any force be recalled into action ſimilar to the vital one. But if the ligature be taken off from the nerve, the force by which the muſcle is put into action is again recovered by it. The nerve being irritated below the place where it is cut, the muſcle to which that nerve goes is contracted. This appears from numerous experiments, eſpecially thoſe made on the phrenic and recurrent nerves.

CCCCIV. This force is not the ſame with the vis inſita. The former comes to the muſcle from without; whereas the other reſides conſtantly in the muſcle itſelf. The nervous power ceaſes when life is deſtroyed; after which the other, from certain experiments, appears to remain a long time: it is alſo ſuppreſſed by tying a ligature upon the nerve, by hurting the brain, or by drinking opium. The *vis inſita* ſuffers nothing from all theſe: it remains after the nerve is tied; and continues in the inteſtines though taken out of the body, and cut in pieces: it appears with great ſtrength in ſuch animals as are deſtitute of brain: that part of the body is moved which has no feeling; and the parts of the body feel which are without motion. The will excites and removes the nervous power, but has no power over the *vis inſita.*

CCCCV. In the motion of the muſcles, whether owing to the *vis inſita* or the nervous power, the fibres are contracted towards the middle of their belly, and recede from one another outwards: they are alſo diverſified with various tranſverſe wrinkles: the whole muſcle alſo becomes ſhorter, and draws its extremities towards the middle; hence it draws towards each other thoſe parts with which it was connected, in the reciprocal ratio of their ſtrength: the muſcle alſo ſwells by its contraction, becoming hard at the ſame time, and as it were increaſes its circumference on every ſide. I have never obſerved it to turn pale. Whether on the whole it is increaſed in bulk, or acquires more in breadth than it loſes in length, is difficult to be known. It draws after it the tendons, which are obſequious to its motions, though of themſelves neither moveable nor irritable. The whole muſcle is alſo capable of being moved at once, or only a part of it: if one extremity is fixed to an immoveable part, that only is moved which is capable of yielding.

CCCCVI. If it be demanded, Whether the arteries conduce any thing to muſcular motion? and whether the palſy, which falls upon the lower limbs after a ligature upon the aorta, be not an argument thereof? we anſwer, Not at all, further than as they conduce to the integrity of a muſcle, or to the conſervation of the mutual ſtructure and habit of the parts, which they ſupply with vapour, fat, &c.: for the irritation of an artery does not affect or convulſe the muſcle to which it belongs; nor does a ligature thereof cauſe a palſy, unleſs after a conſiderable time, when the muſcles begin to be deſtroyed by a gangrene. Moreover, it is impracticable to explain the motion of peculiar muſcles from a cauſe derived with an equal force from the heart to all parts of the body. Laſtly, the influence of the will is confined to the nerves, without reſiding in the arteries or other ſolid parts of the body.

CCCCVII. But the direct manner by which the nerves excite motion in the muſcles, is ſo obſcure, that we may almoſt for ever deſpair of its diſcovery. And firſt, concerning the vis inſita, we do not indeed inquire; as this ſeems to be a more briſk attraction of the elementary parts of the fibre by which they mutually approach each other, and produce as it were little knots in the middle of the fibre. A ſtimulus excites and augments this attractive force, which is placed in the very nature of the moving fibre. The other explanations are hypotheſes. As to nervous veſicles ſwelling by a quicker flux of the nervous ſpirits, they are inconſiſtent with anatomical truth, which demonſtrates the leaſt viſible fibres to be cylindrical, and in no part veſicular; and likewiſe repugnant to the celerity with which muſcular motion is performed, and with the bulk of a muſcle being rather diminiſhed than increaſed during its action. Again, the inflation of rhomboidal chains in the fibres is equally repugnant to the celerity, to inſpection, and to anatomy; they would alſo occaſion an immenſe waſte of ſtrength, and after all render the muſcle but little ſhorter. The nerves want that irritable nature which is obſerved in the muſcular fibre. Finally, it is by no means demonſtrable, that the fibres, from ſo few nerves, can be ſo numerous, or diſtributed in ſo many different tranſverſe directions, with reſpect to the muſcular threads, as thoſe hypotheſes require to be allowed. A complication of the nerves round the extremities of fibres, ſo as to contract them by their elaſticity, is founded upon a falſe ſtructure of the muſcular fibre, ſuppoſing the nerves to be diſtributed, where filaments of the cellular ſubſtance only can be demonſtrated. Moreover, the phenomena of animals, which, having neither brain nor nerves, are yet very apt for motion, apparently demonſtrate the intrinſic fabric of the muſcles to be ſufficient for their motion, without other aſſiſtance from the nerves. Other explanations, derived from ſpherules full of air in the blood, ſuppoſe a falſe nature of that fluid; namely, a repletion of it with elaſtic air, of which it has none, (CCLXXXI.) The animal ſpirits are not of the nature of an electric torrent.

CCCCVIII. If we may add any thing to theſe phenomena, you may ſuppoſe the nervous liquor to be of a ſtimulating nature, by which means it forces the elementary particles of the muſcular fibre to approach nearer to each other. The motive cauſe which occaſions the influx of the animal ſpirits into the muſcle ſo as to excite it into action, ſeems not to be the ſoul, but a law derived immediately from God. For animals newly born, or newly transformed, without any attempt, or exerciſe, know how to execute compound motions, very difficultly to be defined by calculation. But the ſoul learns thoſe things which it does, very ſlowly, imperfectly, and by making experiments. That muſcle then is contracted which in a given time receives more of the nervous fluid, whether that be occaſioned by the will, or by ſome irritating cauſe ariſing in the brain, or applied to the nerve.

CCCCIX. But, though you may conjecture the ſoul to be the cauſe of the nervous motion, you cannot do the ſame with regard to that ariſing from the vis inſita. The heart and inteſtines, alſo the organs of generation, are governed by a vis inſita, and by ſtimuli. Theſe powers do not ariſe from the will; nor are they leſſen-

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ed, or excited, or ſuppreſſed, or changed by the ſame. No cuſtom nor art can make theſe organs ſubject to the will, which have their motions from a vis inſita: nor can it be brought about, that they ſhould obey the commands of the ſoul, like attendants on voluntary motion. It is ſo certain that motion is produced by the body alone, that we cannot even ſuſpect any motion to ariſe from a ſpiritual cauſe, beſides that which we ſee is occaſioned by the will; and, even in that motion which is occaſioned by the will, a ſtimulus will occaſion the greateſt exertions, when the mind is very unwilling.

CCCCX. There ſeems to be this difference between the muſcles obeying the will, and thoſe which are governed by a vis inſita; namely, that the latter, being more irritable, are very eaſily excited into motion by a gentle ſtimulus; as for inſtance, the heart and inteſtines; which organs are moſt manifeſtly, and greatly, and conſtantly, irritable. On the other hand, the muſcles which obey the will, are neither endowed with ſo great nor ſo durable a power of this kind. Hence, they either ſtand in need of the power of the will, or a ſtronger ſtimulus; by which, indeed, when they are excited, even theſe are animated to motion againſt the will. Thus it happens, that, in apoplexies, the muſcles which obey the will languiſh, and become paralytic, as being deſtitute of all influx from the brain; while the vital muſcles, having no occaſion for the operation of the brain, continue to be excited into contraction by their ſtimuli, the heart by the blood, and the inteſtines by the air and aliments.

CCCCXI. The ſtrength of this action in the muſcles is very conſiderable in all perſons, but more eſpecially in thoſe who are phrenetic, and ſome who are called ſtrong men; ſince frequently, with the uſe of a few muſcles only, they will raiſe a weight equal to, or much greater than, that of the whole human body itſelf. For even in one who is in his ſenſes, very ſlender muſcles ſuffice to elevate 200 or 300 pounds. The muſcles of the back will even ſuſtain 3000. Notwithſtanding this, we ſee, that much the greater part of the force or power exerted by a muſcle is always loſt without producing any viſible effect. For all the muſcles are inſerted nearer the point or centre of motion, than the weights they are applied to; and therefore their action is weaker, in the ſame proportion as they move a ſhorter part of the lever than that to which the weight is applied. Moreover, in moſt of the bones, eſpecially thoſe of the limbs, the muſcles are inſerted at very acute angles; whence again the effect which a muſcle exerts in action, is proportionably leſs as the ſine of the angle intercepted betwixt the bone and the muſcle is leſs than the whole ſine. Again, the middle part of all muſcular force is loſt, becauſe it may be reckoned as a cord extended, and drawing an oppoſite weight to its fixed point. Again, many of the muſcles are ſeated in the angle of two bones, from one of which ariſing they move the other; and therefore, that bone being moved, they are bent, and of courſe, like an inflected cord, require a new force to extend them. Many of them paſs over certain joints, each of which they bend in ſome degree, whereby a leſs part of their remaining force goes to bend the joint to which they are particularly deſtined. The fleſhy fibres themſelves of the muſcles frequently intercept angles with the tendon in which they terminate; from whence a great part of their force is loſt, as much as is equal to the difference or deviation betwixt the ſine of the angle of their inſertion and the whole ſine. Finally, the muſcles move their oppoſed weights with the greateſt velocity and expedition, ſo as not only to overcome the equilibrium, but likewiſe to add a conſiderable celerity to the weight.

CCCCXII. All theſe loſſes of power being computed, make it evident, that the force exerted by muſcles in their contraction, is exceeding great beyond any mechanical ratio or proportion whatever; ſince the effect is ſcarce one-ſixtieth of the whole force exerted by the muſcle, and yet only a ſmall number of theſe muſcles, weighing but a few pounds, are able not only to raiſe ſome thouſands of pounds, but alſo with a conſiderable celerity. Nor is this to be reputed any defect of wiſdom in the Creator: For all thoſe loſſes of power were neceſſary towards a juſt ſymmetry or proportion of the parts, with the various motions and celerities required by the muſcles to act in different directions; all which circumſtances bear a relation to the mechaniſm of compound engines. But we may, however, conclude from hence, that the action of the nervous or animal fluid is very powerful, ſince, in an engine ſo ſmall, it can exert a force equal to ſome thouſand pounds for a conſiderable time, or even for many days together; nor does this ſeem to be otherwiſe explicable, than by the incredible celerity by which the influx of this fluid obeys the command of the will. But how, or whence it acquires ſuch a velocity, is not in our power to ſay; it is ſufficient, that we know the laws of its motion are ſuch, that a given action of the will produces a new and determinate celerity in the nervous fluid.

CCCCXIII. The eaſy and ſudden relaxations of muſcles in their motion are aſſiſted by the actions of their *antagoniſt* muſcles. Namely, in all parts of the body every muſcle is counterpoiſed by ſome weight, elaſticity, an oppoſite muſcle, or a humour acting againſt the cavity of a muſcle, by which it is expelled. This cauſe, which is a vis inſita, continually operates as long as the muſcle acts; and ſo ſoon as the additional celerity derived from the brain abates, it reſtores the limb or other part immediately to its former eaſy ſtate, in which there is an equilibrium betwixt the muſcle and its oppoſing cauſe. Whenever the antagoniſt power is removed from the muſcle, there are none of them but muſt contract, extending their oppoſites, by which the diſtended nerves excite an uneaſy ſenſe, and cauſe a ſtronger endeavour towards recovering the equilibrium. Hence one of the flexor muſcles being cut in two, the extenſor operates even in a dead body; and the reverſe.

CCCCXIV. But there are other means, by which the motions of the muſcles are rendered more ſafe, certain and eaſy. The large long muſcles, by which the greater er motions of flexure are performed, being included in tendinous capſules or caſes, drawn and tightened by other muſcles, are thus ſecured and ſtrengthened; for ſo the muſcle remains preſſed againſt the bone, in a ſtate of contraction, all the time that the limb is bent, and avoids a conſiderable loſs of its power. But the long tendons, which are incurvated or extended over joints in their motion, are received and confined by peculiar bands, which retain them within their ſlippery channels, and keep them from ſlipping out under the ſkin; which diſlocation of the tendon, whenever it happens, is attended with a cramp of the muſcle, ſevere pain, and loſs of motion; and in theſe ſheaths a particular liquor is ſeparated for the lubricating of the tendons. The ſame kind of care we obſerve taken by nature in the caſe of muſcles which perforate others in their courſe. In other parts, the tendons are either carried round certain eminences of the bone, in order that they may be inſerted at greater angles into the bone which they move; or elſe they are inſerted into another bone, from whence a different tendon deſcends under a larger angle into the bone to be moved. In other parts, the muſcles which are derived from convenient ſituations, have their tendons carried round in a contrary direction by nature, ſo that they paſs into the part to be moved as it were round a pully. Nature has likewiſe ſurrounded the muſcles on all ſides with fat, which is ſpread alſo betwixt their bundles of fibres and the ſmall fibres themſelves which lie contiguous: which fat, being preſſed out by the turgeſcence of the muſcles and fibres, renders them ſoft, flexible, ſlippery, and fit for motion.

CCCCXVI. Moreover, the power and action of one muſcle is determined by the co-operations or oppoſitions of others, which ſerve either to hold firm ſome part from whence the muſcle ariſes, or to bend it together with the muſcle, or elſe to change its action from the perpendicular to the diagonal, by concurring to aſſiſt its force at the ſame time. The muſcles alſo aſſiſt one another, even thoſe which are ſeparated at a conſiderable diſtance, the firſt keeping the bone firm which is not to be moved, out of which the ſecond ariſe. Therefore, the action of no one muſcle can be underſtood from conſidering it alone; but all the others muſt likewiſe be brought into the conſideration, which are either inſerted into the muſcle itſelf, or into any of the parts to which the ſaid muſcle adheres.

CCCCXVII. By theſe muſcles, variouſly conſpiring and oppoſing each other, are performed walking, ſtanding, flexion, extenſion, deglutition, and all the other geſtures and offices of the ſeveral parts in the living body. But the muſcles have likewiſe ſome common or public actions, by which they are of uſe to the whole animal. They haſten the return of the venous blood, by preſſing it out both from the veins of the muſcles themſelves and from the veins which lie betwixt them; for the blood in theſe veſſels, diſtributed betwixt the turgid bundles of a contracted muſcle, is, by the valves, determined towards the heart only: they likewiſe return the fat to the blood; and ſhake, grind, or condenſe the arterial blood, and return it quicker to the lungs. Again, in the liver, meſentery, womb, &c. they promote the courſe of the contained blood, bile, and other juices, ſo as to leſſen the danger of their ſtagnation: they ſerve alſo to increaſe the ſtrength of the ſtomach, by adding their own ſtrength to it, whereby digeſtion is promoted; inſomuch that all ſedentary and inactive courſes of life are contrary to nature, and pave the way to diſeaſes from a ſtagnation of the humours, or from a corruption or crudity of the aliments. The large muſcles, which are generally placed round any of the cavities of the body, propel the blood contained in that cavity, and preſs it towards the heart. But by too much exerciſe or action, the muſcles themſelves grow hard and tendinous on all ſides; render the parts upon which they are incumbent cartilaginous, or elſe change thoſe which are membranous into a bony nature; increaſe the roughneſs, protuberances, and proceſſes, of the bones which lie next to them, and excavate their flat parts; dilate the cells ſeated in the diplöe, and bend the bones towards theſe parts.

CCCCXVIII. The muſcle which the ſtimulus has ceaſed to irritate, or for the action of which the mind has no occaſion, is relaxed, and grows ſoft; its wrinkles are filled up, and grow plain; its fibres are rendered longer, receding from the middle towards the fixed extremities; and its ſwelling fails. Whatever is the cauſe of additional contraction is then taken away; but that remains, without which the muſcle never is, as long as it is alive. Nor is this the work of an antagoniſt muſcle, although it may be aſſiſted by it. It may be aſked, What becomes of the ſpirit that is ſent forth from the brain? A part of it perhaps exhales; I ſuſpect a part to adhere to the fibre; and thus it happens, that the muſcles grow ſtrong with exerciſe, and their brawny parts become thicker.

CHAP. XIII.

Of the Senſe of TOUCH.

CCCCXIX. THE other office of the brain and nerves is to *feel;* that is, to ſuffer a change from the actions or impreſſions of external bodies, and thereby to excite other correſponding changes or repreſentations in the mind. We ſhall therefore firſt lead our examination to each of the ſenſes in particular [111];

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[111] It is a commonly received opinion that there are five ſenſes; becauſe ſo many different places of the body, which they call *organs of ſenſe*, are affected by a like number of bodies acting upon us. The ſkin is affected by the action of the bodies that touch it, the taſte by ſapid bodies, the noſtrils by odorous bodies, the ears by ſonorous bodies, and the eye by light. Does this diviſion and diſtinction of the ſenſes into five perfectly coincide with nature? Whoever will conſider, that the different tempers of the air, whether they depend on its changed elaſticity or upon its abundance or defect of electric matter, or upon the preſence of vapours, cold, or heat, produce in ſome, yea ſeveral animals and men, ſo manifeſt an effect, that ſome can thence preſage inſtant changes; whoever would conſider the wonderful effects of hunger and thirſt, and likewiſe duly attend

and then conſider what is common to all of them, with the changes which follow in the common ſenſory and in the mind.

CCCCXX. The ſenſe of touch is underſtood in a twofold manner. For, by this term in general, we call all changes of the nerves, ariſing from heat, cold, roughneſs, ſmoothneſs, weight, moiſture, dryneſs, or other affections of external bodies, in whatever part or organ they are applied to cauſe a change. In this ſenſe, the touch is aſcribed to almoſt all parts of the human body, to ſome more, to others leſs; as in different places of the body the nerves are more numerous and bare, or covered with more tender membranes; and thus even pain, pleaſure, hunger, thirſt, anguiſh, itching, and the other ſenſations, belong to the ſenſe of feeling.

CCCCXXI. But, in a ſomewhat different and more proper acceptation, the ſenſe of touch is ſaid to be the change ariſing in the mind from external bodies applied to the ſkin, more eſpecially at the ends of the fingers. For, by the fingers, we more accurately diſtinguiſh the qualities of tangible things than by other parts of our body.

CCCCXXII. Indeed, this ſenſe does not eaſily diſtinguiſh any particles by the ſkin which it does not touch. But ſince the touch is more peculiarly aſcribed to the cutaneous papillæ, therefore the ſtructure of the ſkin is to be firſt deſcribed. That part, then, which is called the *true ſkin*, is compoſed of a thick cellular net-work, whoſe fibres and plates are cloſely compacted and interwove together in an intricate manner, which renders it porous, and capable of contracting or dilating to a ſurpriſing degree. Its ſtrata, when expoſed to the air by turning up the epidermis, become more cloſely compacted together; the ſame is inſenſibly relaxed towards

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attend to the phenomena of the exquiſitely ſenſible parts which are deſtined for generation; he will truly find many arguments for increaſing the number of ſenſes. But if you reflect upon the diverſity of organs, and particularly the diſtribution of the nerves, you will perceive a natural difference in the ear alone and eye.

wards fat, and is reſolved into a ſofter cellular texture. It is more tender in ſome places, and in others more hard. Within this ſubſtance run many ſmall arteries, which come from the ſubcutaneous ones, which, tho' neither large nor of a very great length, are yet numerous in ſome parts of the ſkin, which look red, as in the cheeks; but in other parts they are fewer in number. The veins ariſe in great numbers from the ſubcutaneous net-work, and the nerves likewiſe in the ſkin are very numerous; but they vaniſh ſo ſuddenly, that it is very difficult to trace the ultimate extremities of them. Betwixt the ſkin and muſcles is placed the cellular fabric, into which the ſkin is inſenſibly reſolved, in moſt parts repleniſhed with fat, the little eminences of which preſs upon the ſmall hollows of the ſkin; but in ſome, as the penis, red part of the lips, &c. it is deſtitute of fat. There are very few parts in the body of man where the ſkin is immediately joined to the muſcular fibres without any ſeparation by fat or cellular ſubſtance; for, though the dartos of the teſticle has no muſcular fibres, it is not without the cellular ſubſtance. There are ſome places, indeed, where tendinous fibres are inſerted into the ſkin; as in the neck, in the palms of the hands, and ſoles of the feet.

CCCCXXIII. Throughout the whole ſurface of the ſkin in moſt parts of the body, but with ſome difficulty, you will find it to have a rough appearance after the cuticle is taken off; but in the human body theſe are ſo obtuſe, that, unleſs you underſtand them to be very minute granulations, they are raiſed hardly any viſible height above the ſkin. But in the ends of the fingers there are larger round papillæ ſeated in cavities of the cuticle [112], and receiving nerves very difficulty ſeen; namely, a little mount or protuberance formed of ſmall veſſels, with one or more ſmall nerves wrapped up together in the cellular ſubſtance. Theſe, in the lips and glans penis, after long maceration, appear villous or down-like; and are ſeen moſt evidently of all in the tongue, from the fabric of which we conclude, by analogy with reſpect to the other cutaneous papillæ.

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[112] The cutaneous papillæ, no regard being paid to their difference of ſituation, are all formed from the cellular texture, which ſerves them for a foundation, into which ſeveral furrows of veſſels are directed; and the filament of a nerve, which is eaſily found in the tubercles of the tongue and penis when it reaches this tubercle, is as if ſoftened and abſorbed into a ſponge. Albinus has elegantly repreſented the diverſity of the papillæ.

CCCCXXIV. Over the ſurface of the ſkin is placed another covering, which is not ſo liable to be injured by the air, and which coheres with the ſubjacent ſkin by an infinite number of ſmall bloodleſs veſſels, and by hairs which paſs through its ſubſtance. The outer ſurface of this covering, as it were of an horny fabric, is dry, inſenſible, and not ſubject to putrefaction; but being deſtitute of veſſels and nerves[113], it appears in a particular manner wrinkled and ſcaly, and is joined to the ſkin by a kind of net-work. This is called the *epidermis* or *cuticle*, which is perforated by an infinite number of pores, ſome larger for the ſweat, and others ſmaller for the perſpirable vapours; out of whoſe ducts, expanded and cemented by the interpoſition of a condenſed glue, the ſubſtance of the cuticle is probably compoſed. By preſſure or burning, the cuticle grows thicker, by the addition of new plates or ſcales, formed betwixt the ſkin and thoſe which lie outermoſt; and this is called *a callus*. But even naturally, in Blacks, the cuticle has two diſtinct plates.

CCCCXXV. The inner ſurface of the cuticle is more ſoft and like a pulp, ſomewhat like an half fluid or a concreted mucus; whence, by macerating ſome time in water, it ſeparates from the former, difficultly in Europeans, but eaſily in the Blacks, where it is truly membranaceous, ſolid, and ſeparable, as in the palate of brutes. This ſurface of the cuticle lies incumbent on the ſkin itſelf, whoſe papillæ, in thoſe parts where they are to be found, are received into the ſoft cuticular alveoli or ſockets. This is commonly called *rete Malpighianum*, although it be certain there are no perforations viſible through it like thoſe of a ſieve.

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[113] The nature of the epidermis, the manner of its regeneration, and the controverted aſſertion of the veſſels and nerves preſent in it, have been again propoſed by Malpighius, Boerhaave, and Albinus. Klinkoſch choſe to refer it to a cellular nature: but the great affinity of the epidermis with the hair, nails, and horn, ſufficiently declares its nature; in which neither my injections nor knife have yet been able to diſtinguiſh either veſſels or nerves.

CCCCXXVI. That this reticular body is compoſed of a humour tranſuding from the ſurface of the true ſkin, ſeems very probable. As to the fabric of the cuticle itſelf, it is obſcure; for ſince it is both caſt off, or regenerated, inſenſible, and deſtitute of veſſels, it does not ſeem to belong to the organical parts of the body. Whether is it the outer part of the Malpighian mucus (CCCCXXV.) coagulated and condenſed by the air and by preſſure, after being perforated with a number of exhaling and inhaling ducts, the mouths of which are cemented together by the interpoſed condenſed glue? and whether or not are we perſuaded to this opinion by the mucous expanſion upon the membrane of the tympanum? to which add, the diſſolution of it in water, obſerved by the more eminent anatomiſts; which experiment is by others denied in the cuticle of Blacks.

CCCCXXVII. Moreover, to the hiſtory of the ſkin belong the ſimple glandules, which are ſeated in very many places under the ſkin in the cellular fabric; from whence perforating the ſkin by their excretory duct, they pour out a ſoft half fluid liniment. Other ſebaceous glandules, partly ſimple and partly compound, generate a dry white liniment, of an harder conſiſtence in the face, but more oily in the groins and arm-pits, with which the ſkin being anointed, ſhines, and is defended both from the air and outward attrition. They are found ſeated in all parts of the body that are under a neceſſity of being more immediately expoſed to the air, as in the face, where there are a great number of the compound ſort; or wherever the ſkin is liable to any great attrition, as in the arm-pits, nipples, groins, glans penis, nymphæ, anus, and hams. They frequently ſend out hairs. If it be aſked, Whether theſe follicles are ſeated in all parts of the ſkin? we anſwer, That although anatomy does not every where demonſtrate them, yet it ſeems probable that they are in no part abſent, as may appear from the ſordes collected about the whole ſurface of the body, ſeemingly of the ſebaceous kind. But there is another ſort of liniment poured out upon the ſkin from the fat itſelf, by its particular pores, without the intervention of glands (CCIX.); and this more eſpecially where the ſkin is clothed with hair, as in the ſcalp.

CCCCXXVIII. Again, both the hair and nails are appendages to the ſkin[114]. The former are ſcattered over almoſt the whole ſurface of the body, the palms of the hands and ſoles of the feet excepted; in moſt parts ſhort and ſoft; but longer upon the head, mouth, cheeks, and chin, with the breaſt in men; alſo, upon the fore part of the limbs, in the arm-pits, groins, and pubes. They ariſe from the cellular texture lying under the ſkin, originating from a little bulb which is membranous, ſtrong, vaſcular, and of an oval ſhape, and more lax towards the cellular texture, (and from this baſis the hairs are augmented by veſſels); in which little bulb another bulb lies hid, at firſt roundiſh, but afterwards cylindrical, and ſurrounded with blood. In that ſecond bulb lies the hair, laid over with a fat humour. The hair, with both its cylindrical ſheaths, comes to the cutaneous hole, goes out through the ſame paſſage, and forces the epidermis into a ſimilar ſheath; from whence the incorruptibility of the hair: and then the cover cannot be ſeparated farther from the cortex; but the filaments, and ſpongy and cellular matter, are continued throughout the whole length of the hair. The hairs grow naturally in the cellular ſubſtance under the ſkin; but, by diſeaſe, they are ſometimes formed within the fat of other parts. They grow continually; and are renewed again, after being cut, by a protruſion of their medullary ſubſtance from the ſkin outward, under a production of the cuticle. When the hairs are deſtitute of this medulla in old people, they dry up, ſplit, and fall off. Their colour is from the juice, which fills the internal cellular texture. The ſeem. to perſpire through their extremities, and poſſibly throughout their whole ſurface; as we may conclude from the conſtant force of protruſion in their medulla, which, in the plica Polonica, wants a boundary to terminate it. To which add, the luminous ſtreaks or rays that come out from the hairs of an animal electrified. The ſubcutaneous fat or oil ſeems to follow, and tranſude through the medullary tract and pores of the hairs.

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[114] As the ſcales of the epidermis, or its leſs particles, are differently conformed through the various claſſes of animals, inſects, ſerpents, fiſhes, quadrupeds, and the feathers of birds; ſo alſo it is compared with the hairs, which according to the various claſſes of animals, aſſume a difference of nature; being readily changed into true ſcales, as in fiſhes; into feathers, as in birds; into prickles, as in the hedgehog and porcupine; into ſoft wool, &c. The nature of the hairs has been well deſcribed by Malpighius, Ledermuller, &c.

CCCCXXIX. The *nails* are of the nature and fabric of the cuticle; like which, they are alſo inſenſible, and renewable after being cut or having fallen off. They are found placed upon the backs of the ends of the fingers and toes, which they ſupport to make a due reſiſtance in the apprehenſion of objects, having the nervous papillary bodies, that ſerve the organ of touch, placed under their lower ſurface. They ariſe with a ſquare root, intermixed with the perioſteum, a little before the laſt joints, from betwixt the outer and inner ſtratum of the ſkin; and paſſing on ſoft, go out by a lunar cleft in the external plate of the ſkin, where the cuticle returns back, and is partly laid over the outſide of the nail, together with which it is extended forward as an outer covering. The nail itſelf is of a ſoft tender fabric where it firſt ariſes, partly covered by the ſkin; but, by age and contact with the air, it in time hardens into a ſolid, horny, and elaſtic body, compoſed of long hair-like threads, cemented together by interpoſed glue, and diſtinguiſhable from each other by intervening ſulci or furrows, by which one may be able to ſplit them into a number of leſſer orders. The nail thus formed, extends itſelf to the extremity of the finger; and is, in this tract, lined all along internally within its concave ſurface, by an expanſion of the true ſkin, and ſubjacent perioſteum intermixed; the filaments of which ariſe firſt ſhort, and are afterwards continued of a greater length, till they become longeſt of all at the extremity of the nail to which they cohere. Theſe are moſt intimately connected into the root of the nail. Over the outer ſurface of the nail ſome part of the ſkin is again at liberty, and lies under the nail, and diſtinct from it, and has its own epidermis. A furrowed net-work is interpoſed betwixt the ſkin and nail, which is alſo eaſily ſeparable and ſoft, for the protection of the papillæ; from thence the furrows grow gradually harder, ſo that at laſt they can ſcarce be diſtinguiſhed from the nail. The tendons do not reach quite ſo far as the nail.

CCCCXXX. The cellular ſubſtance is without fat, except in a few places to allow a neceſſary motion to the ſkin. Where it is repleniſhed with the fat, it ſerves to defend the warmth of internal parts from the cold air; to render the ſkin moveable upon the muſcles; to fill up the cavities betwixt the muſcles themſelves; and to render the whole body white and uniform. The ſkin, cuticle, and its Malpighian mucus, ſerve not only to limit the external bounds of the body every where; but likewiſe, where they ſeem to be perforated, paſſing inward, they degenerate by degrees[115]. For the cuticle is manifeſtly extended into the anus, urethra, vagina, cornea of the eye, auditory paſſage, mouth, and tongue; nor is it wanting even in the ſtomach itſelf and inteſtines; although, by the perpetual warmth and moiſture, its fabric be altered, and extended or relaxed into their villous covering. Thus the true ſkin is continued into the internal fabric of the palate, tongue, pharynx, noſtrils, vagina, &c. where it degenerates always into a white, thick, pulpy, commonly called nervous, coat of thoſe parts.

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[115] All the parts of the ſkin are not continued upwards through all the holes and openings; for the epidermis is different in the cornea, inteſtines, larynx, and urethra: the ſame holds of the reticula, and of the coriaceous part of the ſkin: the mucous follicles likewiſe make a great difference in the internal places; whereas they are ſebaceous cryptæ externally. The learned Boon has thrown much light upon this ſubject.

CCCCXXXI. What has been hitherto advanced, is ſufficient to enable us to underſtand the nature of touch. The papillæ, ſeated in the larger winding ridges at the ends of the fingers, regularly diſpoſed in ſpiral folds, are, by the attention of the mind, a little raiſed or erected; as appears from frights or ſhiverings; as we ſee in the nipples of women, in the handling of tangible objects, and by light friction; whereby, receiving the impreſſion of the object into their nervous fabric, it is thence conveyed, by the trunks of the nerves, to the brain. This is what we call the *touch*, whereby we become ſenſible chiefly of the roughneſs of objects; in which ſome perſons have ſo ſharp a ſenſation, that they have been known to diſtininguiſh colours by touching the ſurface only. By this ſenſation we perceive heat, when it exceeds in bodies the heat of our fingers; and weight likewiſe, when it preſſes more than is uſual. Humidity we judge of by the preſence of water; ſoftneſs, by a yielding of the object; hardneſs, from a yielding of the finger; figure, from the limits, or rough circumſcribed ſurface; diſtance, from a rude calculation or eſtimate made by experience, to which the length of the arm ſerves as a meaſure: ſo the touch ſerves to correct the miſtakes of our other ſenſes; but yet it ſometimes errs itſelf, and then the other ſenſes ſhow themſelves to be true guides to the animal without that of touch.

CCCCXXXII. The mucous body of Malpighius moderates the action of the tactile object, and preſerves the ſoftneſs and ſound ſtate of the papillæ. The cuticle excludes the air from withering and deſtroying the ſkin; qualifies the impreſſions of bodies, ſo that they may be only ſufficient to affect the touch, without cauſing pain: and therefore, when it is become too thick by uſe, the ſenſe of feeling is either loſt or leſſened; but if it be too thin and ſoft, the touch becomes painful. The hairs ſerve to defend the cuticle from abraſion; to preſerve and increaſe the heat; to cover and conceal ſome parts, and render the membranes of others irritable, which nature required to be guarded from the entrance of inſects; and perhaps they may ſerve to exhale ſome uſeleſs vapours, or afford a paſſage to the exhaling oil. The nails ſerve to guard the touch, that the papillæ and ends of the fingers may not be bent back by the reſiſtance of tangible objects: at the ſame time they increaſe the power of apprehenſion, and aſſiſt in the handling minute objects. In brute animals, they generally ſerve as weapons of offence, and might be of the ſame uſe to man, if they were not cut off.

CCCCXXXIII. But theſe are not all the uſes of the ſkin. For one moſt important office of that covering is to exhale from the body a large quantity of humours and other matters to be carried off by the air. Accordingly, the whole ſurface the ſkin, ſweats out a vapour by an infinite number of ſmall arteries, either coiled up into papillæ or ſpread on the ſkin itſelf, which paſs out, and exhale through correſponding pores of the cuticle; although the courſe or direction of the veſſels which pour out this vapour be changed in paſſing from the ſkin to the cuticle. Theſe exhaling veſſels or arteries are eaſily demonſtrated by an injection of water or fiſh-glue into the arteries; for then they ſweat out from all parts of the ſkin an infinite number of ſmall drops, which being transfuſed under the cuticle, rendered impervious by death, raiſe it up into a bliſter.

CCCCXXXIV. In a living perſon, this exhalation is many ways demonſtrable. A clean looking-glaſs placed againſt the warm and naked ſkin, is quickly obſcured by the moiſt vapour. In ſubterraneous caverns, where the air is more denſe, it more plainly goes off into the air, from the whole ſurface of the body, in the form of a viſible and thick cloud.

CCCCXXXV. Whenever the motion of the blood is increaſed, while at the ſame time the ſkin is hot and relaxed, the ſmall cutaneous pores, inſtead of an inviſible

viſible vapour, diſcharge *ſweat*, conſiſting of minute, but viſible drops, which run together into larger drops by joining with others of the ſame kind. But thoſe parts chiefly are ſubject to ſweat which are hotteſt; that is to ſay, where the ſubcutaneous arteries are largeſt, and have a greater action from their reſiſtance, as in the head, breaſt, and foldings of the ſkin. The experiment before mentioned (CCCCXXXIII.), together with the ſimplicity of nature herſelf, joining with the viſible thickneſs or cloudineſs of the cutaneous and pulmonary exhalation (CCCCXXXIV.), ſufficiently perſuades us, that the perſpirable matter and ſweat are diſcharged through one and the ſame kind of veſſels, and differ only by the quantity and celerity of the matter. But together with the ſweat is intermixed the humour of the ſebaceous glands (CCCCXXVII.) and the ſubcutaneous oil, which being more plentifully ſecreted, and diluted with the arterial juice, flows out of an oily and yellow conſiſtence, and chiefly gives that ſmell and colour to the ſweat for which it is remarkable. Hence we find it more fetid in the arm-pits, groins, and other parts, where thoſe glandules are moſt numerous or abundant. Both blood and ſmall ſand have been known to proceed from the ſkin along with the ſweat.

CCCCXXXVI. Concerning the nature of *perſpiration*, we are to inquire by experiments and by analogy with the pulmonary exhalation, which more frequently and abundantly perſpires a vaporous cloud of the ſame kind, more eſpecially viſible in a cold air. That what flies off from the body in this exhalation is chiefly water, appears from experiments, by which the breath, being condenſed in large veſſels, forms into watery drops. Agreeable with this, we find the obſcuring vapour condenſed by a looking-glaſs to be extremely ſubtle, ſo as wholly to fly off again from it; and the ſame is confirmed by the obſtructed matter of perſpiration paſſing off by urine, or frequently changing into a diarrhœa; and from the eaſy paſſage of warm liquors in the form of perſpiration by a hot air, or elſe by the urinary paſſages in a cold air. The water of theſe vapours is chiefly from what we drink, but is in part ſupplied from the inhalation of the ſkin. Frequently, even the particular ſmell of the aliments may be plainly perceived in the perſpiration; and there is alſo an admixture of the electrical matter in every perſon, but in ſome it is more evidently lucid[116].

CCCCXXXVII. But that there are, beſides water, ſome volatile particles intermixed of an alkaline nature, is evident as well as from the nature of our blood, as the conſiderable miſchiefs which follow from a retained perſpiration. This volatile alkaline matter ariſes from the finer particles of the blood, attenuated by perpetual heat and tritùre, and changed into an acrimonious nature. Theſe afford the ſcent which is cloſely followed by dogs, who would not know their maſters unleſs ſomething of a particular nature perſpired from each perſon.

CCCCXXXVIII. The quantity of our perſpiring moiſture is very large, whether we conſider the extent of the organ by which it is ſeparated, the abundance of vapours derived from the lungs only; or barely take a review of the experiments made by Sanctorius, in which five pounds out of eight, but by other experiments in a colder country from fifty-ſix to thirty ounces, of the food and drink taken into the body in a natural day, were found to fly off by perſpiration only, excluſive of any of the viſible diſcharges, and without making any addition to the weight of the body; but from this weight you muſt deduce that of the ſaliva, mucus of the noſe, and ſweat. But the cutaneous exhalation is even much larger than this; ſince it not only throws off ſuch a quantity of the indigeſted food and drink, but likewiſe what is added to the blood by the way of inhalation (CCCCXLII.),

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[116] It is not yet experimentally proved, whether all the electric matter which we inhale from the air, is communicated ſolely by the lungs, which is the opinion of the celebrated Dagoty; or whether, at the ſame time, we take ſome in by the ſkin: perhaps a greater quantity of this matter is carried off by means of perſpiration through the ſkin, and hence ariſes the lucid nature of certain bodies.

(CCCCXLII.), which entering, often in a very conſiderable quantity, is thus again expelled. But different diſpoſitions of the air, and of the human body, cauſe great variations in thoſe matters. In warm countries, in the ſummer-months, and in young exerciſed perſons, more goes off by tranſpiration from the body, and leſs by the urine. But in cold climates, during the temperate or winter ſeaſons, in aged or inactive perſons, more goes off by the urine than by the inſenſible diſcharge. But in temperate countries, making a computation throughout the whole year, ſomething more is perſpired than what paſſes off by urine; and joining together all the experiments made in different countries, both excretions are almoſt alike. The difference of time after feeding does alſo in ſome meaſure vary the quantity tranſpired; but in general it is moſt copious at that time when the greater part of the digeſted nouriſhment is conveyed into the blood, and there attenuated ſo as to be fit for exhalation. It is naturally diminiſhed in ſleep, even in the warmer climates; but it is increaſed by the heat of bed-cloaths.

CCCCXXXIX. In general, a plentiful and uniform perſpiration, with ſtrength of body, are good ſigns of health; for whenever it abounds from too great weakneſs, it is obſerved to do more miſchief than none at all, if the writings on that head are ſufficiently to be depended on. It is thus a ſign of health, becauſe it denotes a free pervious diſpoſition of the veſſels diſperſed throughout the whole body, together with a complete digeſtion of the nouriſhment, the greater part of which is perfectly attenuated into a vapour. When it is diminiſhed, it indicates either a conſtriction of the ſkin, a weakneſs of the heart, or an imperfect digeſtion of the aliments. Perhaps in too great a perſpiration the nervous ſpirits themſelves are evaporated. This diſcharge is, by moderate exerciſe, increaſed to ſix times that of an idle perſon, even to an half or whole pound in an hour, aided by ſtrong and open veſſels, by warm, watery, and vinous drinks, with animal food of an eaſy digeſtion, and a heavy, temperate, or moderately warm air, aſſiſted with joyful affections of the mind. The contrary of theſe either leſſen or ſuppreſs the perſpiration; as thick ſkin, a moiſt air, or a cold and dry one, with reſt, more frequent bathing than uſual, or from a diarrhœa ſuddenly ariſing, and laſtly from a nervous concuſſion from a diſagreeable affection of the mind. However, the continuance of life does not depend on a ſcrupulous exactneſs in the quantity of this diſcharge, which is ſo eaſily increaſed or diminiſhed by ſlight cauſes; which is ſhut up by paints in many Indian nations, and is inconſiderable in many animals without any ſenſible injury. When it is ſuppreſſed, it does a prodigious deal of miſchief in fevers of a bad kind; it hurts chiefly by its putreſcent qualities, which are retained by ſuppreſſed perſpiration.

CCCCXL. The ſweat is evidently of a ſaline nature; as appears both from the taſte, and from the minute cryſtals which ſhoot upon the cloaths of ſuch as work in glaſs-houſes; as well as by diſtillation, which ſhows the ſweat to be of an alkaline nature. Hence it is, that by this diſcharge the moſt malignant matter of many diſeaſes is thrown off from the body. But, in reality, ſweat is always a preternatural or morbid diſcharge, from which a perſon ought always to be free; unleſs by violent exerciſe, or other accidents, his conſtitution is for a ſhort time thrown into a diſeaſed ſtate. Nor is it unfrequent for ſweats to do conſiderable miſchief in acute diſeaſes; by waſting the watery parts, and thickening the reſt of the blood, at the ſame time that it renders the ſalts more acrimonious. By a too violent motion of the blood, the ſweat is rendered extremely fetid; and is ſometimes even red, or mixed with blood itſelf: being electrized, it ſometimes is lucid.

CCCCXLI. The uſes of perſpiration are, to free the blood from its redundant water, and throw out thoſe particles, which, by repeated circulations, have become alkaline or otherwiſe acrimonious; and poſſibly to exhale therewith an extremely volatile oil, prepared from the ſame blood. The ſame perſpiration likewiſe qualifies and ſoftens the cuticle, which is a neceſſary medium extended before the tender ſenſible papillæ.

CCCCXLII. But the ſame ſkin that makes this exhalation into the air, is likewiſe full of ſmall veſſels, which inhale or abſorb thin vapours from the air, either perpetually, or at leaſt when it is not very cold; more eſpecially when the air is damp, the body unexerciſed, the mind oppreſſed with grief, or both under conditions contrary to thoſe which increaſe perſpiration beforementioned (CCCCXXXVIII.) Theſe veins are demonſtrated by anatomical injections, which, if thin or watery, ſweat through them as through the arteries, if it was watery and thin: moreover, the manifeſt operation of medicines, pervading the air, or applied to the ſkin, prove the ſame; ſuch as the vapours of mercury, turpentine, ſaffron, Bath-waters, mercurial plaſters, tobacco, coloquintida, opium, cantharides, arſenic, with the fatal effects of contagious or other poiſons entering through the ſkin; as in the venereal infection: to which add, the living of animals almoſt without drink in hot iſlands, which abound with moiſt vapours; from which, however, they ſweat and piſs plentiful enough. Laſtly, ſome extraordinary morbid caſes have demonſtrated this, in which a much greater quantity of urine has been diſcharged than the quantity of drink taken in; in which you may believe that the moſt open paſſages ſerved for inhalation; that new ones were generated, is not credible. The proportion of this inhalation is difficult to aſſign; but that it is very great in plants, more eſpecially in the night-time, appears evidently from certain experiments.

CCCCXLIII. Theſe cutaneous veſſels, both exhaling and inhaling, are capable of contraction and relaxation by the power of the nerves. The truth of this appears from the effects of paſſions of the mind; which, if joyful, increaſe the circulation, and relax the exhaling veſſels, ſo as to yield eaſier to the impulſe of the blood; from whence, with a ſhortening of the nerves, there follows a redneſs, moiſture, and turgeſcence of the ſkin. Thoſe paſſions, on the contrary, which are ſorrowful, and retard the circulation, contract the exhaling veſſels; as appears from the dryneſs and corrugation of the ſkin, like a *gooſe-ſkin*, after frights; and from a diarrhœa cauſed by fear. But the ſame affections ſeem to open and increaſe the power of the inhaling veſſels, whence the variolous or peſtilential contagions are eaſily contracted by fear.

CHAP. XIV.

Of the TASTE.

CCCCXLIV. THE organs of taſte and touch differ but ſlightly. By certain experments it appears, that the power of taſte is exerciſed by the tongue chiefly[117]; for even ſugar applied to any other part of the mouth, excites ſcarce the leaſt ſenſe of taſte in the mind: neither will any other ſapid body, unleſs it contains ſomething vehemently penetrating; in which caſe the palate, root of the tongue, uvula, and likewiſe the œſophagus, are affected with the taſte. That ſenſation which is ſometimes excited in the ſtomach, œſophagus, and fauces, by the regurgitation of the aliments, ſeems alſo to belong to the tongue; to which the ſapid vapours are ſent back, uncommonly acrid and penetrating: and even that ſenſe which is ſometimes occaſioned in the ſtomach, œſophagus, and fauces, from a riſing of the aliments, ſeems alſo to be owing to the tongue, to which the taſtable vapours are conveyed.

CCCCXLV. Only the upper and lateral edges of the *tongue* are fitted to exerciſe the ſenſe of taſte. But by the *tongue* we underſtand a muſcular body, broad and ſulcated in man, and lodged in the mouth, whoſe poſterior and lower parts are variouſly connected to the adjacent bones and cartilages, while it remains moveable in its anterior and upper part. In thoſe portions of the tongue, which make the organ of taſte, the ſkin grows to the adjacent muſcular fibres, being continued from the ſkin of the face and mouth; only here it is always ſoft and pulp-like, from the perpetual warmth and moiſture. From this ſkin ariſe innumerable nervous *papillæ*, of a more conſiderable bulk here than in other parts. Of theſe there are ſeveral kinds: the firſt of them are diſpoſed in a rank on the back part of the tongue, on each ſide of the foramen cæcum[118]. Theſe, ſurrounding that opening like a circle, are for the moſt part like an inverted cone, having a deep ſinus in their middle; but are otherwiſe hard, and but indifferently diſpoſed for taſting, although you can eaſily trace the nerves to them. There are ſome other papillæ of the ſame kind found ſcattered before theſe upon the back of the tongue.

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[117] Nowhere indeed upon the ſkin, when the epidermis is taken off, do we feel the taſte of bodies; but taſte is by no means confined to the tongue alone. For on whatever part of the mouth, palate, or cheeks, you apply a ſapid body, you will not perceive the ſenſe of pain, but of the taſte; even of ſome bodies, as arum, pepper, &c. it will be ſtronger and more diſtinct than any where elſe.

CCCCXLVI. Theſe degenerate into a kind of papillæ like muſhrooms, leſs and ſlenderer than the former, of a very cylindric and ſomewhat oval figure, placed at ſome ſmall diſtance from each other, upon the upper ſurface of the tongue, where they grow ſharper pointed as they lie more forwards, and are moſt numerous on the ſides of the tongue. The third ſort of papillæ are of a conical figure, which abound moſt in number among the former, and are ſpread largely over the tongue. Theſe have their apices ſomewhat inclined and fluctuating before, towards the tip of the tongue; theſe are likewiſe moſt numerous in the ſides of the tongue, though there are ſome alſo behind the blind foramen. They are highly ſenſible, and make the true organ of taſte: other papillæ intervene, which are partly conical, and partly ſhaped like threads; and ſome of the conical ones are greater, and the others grow always leſs and leſs[119].

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[118] The number of theſe papillæ vallatæ are by no means conſtant; for the moſt part they are ſeven or eleven, the middle one of which is on the very foramen cæcum: however, it is not rare to find a greater number, and then it is increaſed beyond fifteen or ſeventeen.]

CCCCXLVII. Theſe papillæ have doubtleſs ſmall nerves detached into them, beſides numerous veſſels, although they are difficult to trace; for we obſerve, that larger nerves go to the tongue than almoſt in any inſtance which we have in other parts. For beſides the nerve of the eighth pair, which, being one of the principal of the three branches, deeply enters the baſis of the tongue, covered by the cerato-gloſſus, near the os hyoides, there is alſo a conſiderable nerve that goes to the tongue and its muſcles, from the ninth pair; which having inoſculated with the firſt nerve of the neck, and with the large cervical ganglion, it ſends a branch downward, and frequently joins the eighth pair; but conſtantly communicates with the ſecond and third of the neck, from whence its branches aſcend to the muſcles ariſing from the ſternum, and frequently communicate with the phrenic nerve; after which, the reſt of its trunk goes to the tongue[120]. This communicates, by many branches, with the fifth pair in the cerato-gloſſus, and is more eſpecially ſpent on the genio-gloſſus. Laſtly, the third branch of the fifth pair having ſent up or received the cord of the tympanum, and given other branches to the internal pterygoides, with the maxillary and ſublingual glands, paſſes with its principal trunk behind the cerato-gloſſus, where it joins the ninth pair, and enters the tongue deeply, in company with the artery; together with which it is extended to the tip of the tongue, where it becomes cutaneous. To this nerve, therefore, if there be any prerogative or preference, the ſenſe of taſte is to be more eſpecially aſcribed, which is confirmed from obſervations on ſome difdiſeaſes[121]. Laſtly, the nipples or papillæ of the tongue are of a hard texture, each papilla having its pulpy fabric made up by a number of ſmall nerves, arteries, and veins, conjoined or wound up with a firm cellular ſubſtance into a button, or protuberance, of which many are required to make up one large papilla.

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[119] Albinus has properly added to theſe three claſſes of papillæ a fourth, which lies on the ſides of the tongue, and conſiſt of ſmall, almoſt concentric ſlits, again interſected into ſmaller ones: theſe pretty clearly ſhow the tongue's analogy with the ſkin.

[120] In ſeven bodies one is found, in which a filament goes from the ninth pair to the phrenic.

CCCCXLVIII. The arterial and venous down which runs between the papillæ are for the purpoſes of exhalation; and have nothing to do with the taſte, farther than that they ſeparate from the blood a liquor fit for diſſolving ſalts, and keeping moiſt the papillæ proper for taſte: this liquor they pour out on the back of the tongue. On the upper and back part of the tongue are ſeated many ſimple, round, muciferous glands, having one or more open outlets, which are completed by an hemiſpherical membrane, and the fleſhy part of the tongue. Some of theſe open into the obſcure, blind, and uncertain figured hollow, which is placed in the middle between the largeſt papillæ (CCCCXLV.), and commonly contains ſome of them.

CCCCXLIX. Over the papillæ of the human tongue is ſpread only a ſingle mucous and ſemipellucid covering, which ſtrictly adheres to them, and ſerves them as a cuticle. But, in brute animals, a perforated mucous network receives the papillæ, which are in a manner wrapped up in caſes or capſules of this mucous body covered with the cuticle.

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[121] In moſt of the ſenſitive organs, it is confirmed and proved by long experience, that, out of ſeveral nerves going to an organ, one only ſerves for exerciſing ſenſe: that the optic conſtitutes the primary ſeat and inſtrument of ſight, though we know that ſeveral nerves enter the eye: that the portio mollis is the nerve fitted for hearing, although the portio dura likewiſe paſſes through the ear: that the olfactory nerve does the office of ſmell, notwithſtanding a remarkable number of branches coming from the fifth pair to the membrana pituitaria: and ſo in like manner the ninth pair or middle lingual is appointed for taſte, although conſiderable portions from the gloſſopharyngæus and fifth pair are diſtributed through the tongue. With all this I agree; but the noted hiſtory of Columbus has too fully proved, that little credit is to be given to morbid affections, when inveſtigated and aſſerted by ſingle obſervations alone.

CCCCL. Under thoſe papillæ are ſpread the muſcles which make the fleſhy body of the tongue; which are very numerous, and hardly extricable in the human tongue: in the lower part, it is in a great meaſure made up of the genio-gloſſus muſcle extended outwards from the meeting of the chin, and diſtributed like rays into the ſubſtance of the tongue. The upper and lateral parts are compoſed of the ſtylo-gloſſus, whoſe fibres run to the tip of the tongue; which in its middle part, betwixt the former muſcles, is compoſed of one proper to itſelf, called *lingualis;* which ariſing from before the pharynx and origin of the ſtylo-gloſſus, only lower, goes out forward, and, terminating betwixt the ſaid genio-gloſſus and ſtylo-gloſſus, makes up a very conſiderable part of the tongue. The back part of the tongue is made up of the fibres of the cerato-gloſſus, which aſcend upward and backwark; which ends between the ſtylo-gloſſus and lingualis, being included between them: and to this is joined the chondro-gloſſus, a muſcle entirely different, which ariſes from the ſmall bones, and next adjacent baſis of the os hyoides; from whence paſſing outward, with its lateral portions, covered by the genio-gloſſus, it joins the ſtylo-gloſſus, and diſappears in the tongue. By the action of theſe muſcles the whole tongue is moveable in all directions, and capable of figuring its own ſubſtance, ſo as to form a hollow, by the elevation of the ſtylo-gloſſi, which it again flattens by the cerato-gloſſi, but contracts itſelf into a narrow and almoſt cylindrical figure, by the tranſverſe fibres from one ſide to the other, together with which there are many other orders of fibres, intermixed with a thick fat, ſo that they cannot be traced in the human tongue.

CCCCLI. The *arteries* of the tongue are numerous. One that is larger and deeper aſcends in a ſerpentine courſe from the outer carotid, and extends to the tip of the tongue; and a leſſer ſuperficial artery, incumbent on the ſublingual gland, either ariſes from, or inoſculates with, the preceding. Behind, there are various ſmall branches derived from the poſterior labials; and from the branches proper to the lips, or thoſe of the tonſils. The veins of the tongue are variouſly wove, and difficult to deſcribe; ſome of which, lying deep, accompany the nerve of the ninth pair; and others, that are ſuperficial, accompany the mental artery, and, inoſculating with the former, ſends out the ranular vein; but all of them meet together in a large vein, which is one branch of the internal jugular coming from the brain. Theſe veins variouſly communicate with the adjacent networks belonging to the tonſils, pharynx, thyroide gland, and ſkin; and in the back of the tongue, before the epiglottis, there is a communication betwixt the right and left ſide of the venal plexus. I find lymphatic veſſels rather in the neighbourhood of the tongue than in the tongue itſelf.

CCCCLII. The *papillæ* of the tongue, which are larger and ſofter than thoſe of the ſkin, perpetually moiſt, perform the office of touch more exquiſitely than thoſe of the ſmall and dry cutaneous papillæ; and from hence the tongue is liable to a ſharper degree of pain: moreover, naked ſalts are not otherwiſe perceived than under a ſenſe of moiſture, or of pain. But the papillæ of the tongue being raiſed a little protuberant, to perform the office of taſte, from ſalts diſſolved in water, or ſaliva, and applied againſt their tips or ſummits, are affected in a particular manner; which being diſtinguiſhed by the mind, and referred to certain claſſes, are called *taſtes*, either ſour, ſweet, rough, bitter, ſaline, urinous, ſpirituous, aromatic, or pungent and acrid, of various kinds, inſipid, putrid, and others reſulting partly from pure ſalts, and in part from an intermixture of the ſubtile animal or vegetable oils, variouſly compounding and changing each other. If it be inquired, Whether the diverſity of taſtes ariſes from the different figures which are natural to ſalts[122]? and whether this does not appear from the cubical figure in which ſea-ſalt ſhoots, the priſmatical figure of nitre, or the particular configuration of vitriol, ſugar, &c.? we anſwer, That this does not ſeem probable, for even taſteleſs cryſtals have their particular configurations; and the taſte ariſing from very different ſalts, and differently qualified objects of this ſenſe, are too much alike each other, and at the ſame time too inconſtant or changeable, to allow ſuch a theory; as for example, in nitre. The mechanical reaſon, therefore, of the diverſity of taſtes, ſeems to reſide in the intrinſic fabric or appoſition of their elements, which do not fall under the ſcrutiny of our ſenſes.

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[122] Whoever would compare the elegant obſervations of Baker, Ledermuller, Luchtmans, and Gleichen, upon the figures of ſalts, will

CCCCLIII. But the nature or diſpoſition of the covering with which the papillæ are clothed, together with that of the juices, and of the aliments lodged in the ſtomach, have a conſiderable ſhare in determining the ſenſe of taſte; inſomuch, that the ſame flavour does not equally pleaſe or affect the organ in all ages alike, nor in perſons of all temperatures; nor even in one and the ſame perſon at different times, who ſhall be differntly accuſtomed in health or variouſly diſeaſed. In general, whatever contains leſs ſalt than the ſaliva itſelf, ſeems inſipid.

CCCCLIV. The ſpirituous parts, more eſpecially of vegetables, either penetrate into the papillæ themſelves, or elſe are abſorbed by the adjacent vilii of the tongue; as may appear from the ſpeedy reſtitution of the ſtrength by vinous or aromatic liquors of this kind, even before they are received into the ſtomach.

CCCCLV. Nature deſigned the difference of taſtes to be felt by the tongue, that we might know and diſtinguiſh ſuch foods as are moſt ſalutary: for in general, there is not any one kind of aliment healthy that is of a diſagreeable taſte; nor are there any ill taſted matters that are fit for our nouriſhment. For it muſt be obſerved, that we here take no notice of exceſs, by which the moſt healthy

will be grieved to imagine, that ſo ſimple and eaſily conceived a theory is not capable of explaining the diverſity of taſtes.

healthy food may be prejudicial. In this manner nature has invited us to take neceſſary food, as well by the pain called *hunger*, as by the pleaſure ariſing from the ſenſe of taſte. But brute animals, who have not like ourſelves the advantage of learning from each other by inſtruction, have the faculty of diſtinguiſhing flavours more accurately, by which they are admoniſhed to abſtain cautiouſly from poiſonous or unhealthy food; and therefore it is that herbivorous cattle, to which a great diverſity of noxious plants is offered amongſt their food, are furniſhed with ſuch large and long papillæ of ſo elegant a ſtructure in the tongue, which are not ſo neceſſary to man.

CHAP. XV.

Of SMELLING.

CCCCLVI. THE ſenſe of ſmelling likewiſe conduces to the diſtinguiſhing prejudicial from ſalutary food. By it we both diſcover and are admoniſhed to avoid, before it comes to our taſte, what might be otherwiſe dangerous: and we are eſpecially enabled to avoid any thing of a putrid tendency in our victuals, which to us is of a moſt peſtilent nature, and likewiſe to diſcern what are grateful and wholeſome aliments; although cuſtom has rendered it more remarkable among brute animals than among men. For men who have been brought up wild by themſelves, without debauching the ſcent by a variety of ſmells, have been obſerved to poſſeſs that diſtinguiſhing faculty in a very infallible degree. Finally, the powers and virtues of medicinal plants are hardly to be better known than by the ſimple teſtimony of taſting and ſmelling. From hence it is, that in all animals theſe organs are placed together; and from hence the ſmelling is ſtronger, and the organs larger, in thoſe animals which are to ſeek their prey at a conſiderable diſtance, or to reject malignant plants from among thoſe that are fit for food.

CCCCLVII. The ſenſe of ſmelling is performed by means of a ſoft pulpy membrane, full of pores and ſmal veſſels, which lines the whole internal cavity of the noſtrils, being thicker upon the ſeptum and principal convolutions, but thinner in the ſinuſes. Within this membrane are diſtributed abundance of ſoft nerves throughout the middle of its fabric, from the firſt pair (CCCLVII.)[123], which deſcend through the holes of the os cribroſum into the ſeptum narium; but in ſuch a manner, that it is very difficult to trace them to their extremities and into the ſeptum. Other lateral nerves come from the ſecond branch of the fifth pair and its branches, from that which lies tranſverſe in the pterygoide canal, and from another which deſcends through the canals of the palate; and ſome from the infraorbital branch in the maxillary ſinus, from the dental branch, and from the anterior nerve of the palate. Moreover, the fore-part of the ſeptum has a ſmall twig from the ophthalmic of the firſt branch belonging to the fifth pair[124].

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[123] To end the diſpute, whether the olfactory nerve be hollow, as Hoffman, Collins, Slevogt have aſſerted, and which Vieuſſens, Brunner, and Haller have denied; it is to be obſerved, that in ſome caſes it is found quite hollow, ſo that it may be diſtended by blowing in at the cribriform plate. A caſe of this kind M. Sommering ſaw along with me: but in moſt ſubjects I found it ſolid, and unable to be diſtended by any means.

[124] We ſee diſtinctly the little twigs of nerve, which enter the inſide of the noſtrils from the fifth pair. Haller has already ſpoken of the pterygoide and palatine ramifications. I have ſeen ſent off from the infra-orbitalis two, three, or four filaments, along with the accompanying veſſels, through that part of the membrana pituitaria which covers the antrum Highmorianum. From the ophthalmic branch, beſides the ethmoidal nerves which run through the membrana Schneideriana of the ethmoidal cells, and may be diſtinguiſhed by an elegant whiteneſs, I have ſeen in ſome bodies, ſpecimens of which I have now by me, a branch ſent off from the frontal branch before it has become the ſupra trochlearis, which, along with the infra-trochlearis, turns from the naſal into a ganglion, from which a twig runs into the frontal ſinus. Blumenback has already mentioned this nerve according to my obſervation. The reaſon, perhaps, why it is not found in all ſubjects, is owing partly to its own tenderneſs and ſmallneſs, and partly to the violence uſed in the ſeparation of the bone.

CCCCLVIII. The arteries which go to the noſe are many: from the internal maxillary branches; from the three naſal ones, to wit, the upper and both ethmoidal branches; alſo from the frontal, naſal, and ſide branches; from the leſſer ophthalmic branch of the internal carotid; from branches of the palatine artery; from the infra-orbital within the ſinuſes; and from the ſuperior dental one. It is proper to theſe arteries very eaſily and very plentifully to ſweat out blood, without any conſiderable injury to the veſſels themſelves. The veins run together in company with arteries, and form a large plexus, by uniting upon the external pterygoide muſcle, and communicate with the ſinuſes of the dura mater; from whence they open together into the outer branch of the internal jugular. The arteries ſupply the nouriſhment, warmth, and mucus, neceſſary to theſe parts.

CCCCLIX. The formation of the human head into that of a roundiſh figure, has in us given to the organ of ſmelling but a ſmall extent of ſurface[125]; but to enlarge this the more, nature has made the internal parts of the noſe variouſly hollow and complicated, in a ſurpriſing manner. Firſt then, by the *nāres* we underſtand the multiform cavity, which begins before from the noſtrils, and, extending tranſverſely backward over the roof of the palate under the os cribroſum, terminates at the cavity of the fauces. This cavity is divided into two by a ſeptum or partition of bone, which deſcends above from the plate of the cribroſum, but below is formed by the vomer, and in its fore-part is completed by

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[125] I am always ſtruck with admiration, when I compare the organs of ſmell in ſome quadrupeds with thoſe of man. For as in man the cavity of the cranium, which is the ſeat of the brain, is to the face almoſt as three, or two to one; but in brutes, as the horſe, cow, ſow, as one almoſt to ſix, eight, or nine; ſo in man the circumference of the noſtrils is to the whole globe of the head as one to fourteen or ſixteen; in brutes, on the contrary, as three or two to one; or in ſome, as one to one. Therefore, the anatomical reaſon is plain, why moſt animals ſmell more acutely than man, although he may have weakened his ſmelling by no bad cuſtom.

by a triangular cartilage, whoſe ſurface is largely extended and very ſenſible.

CCCCLX. Moreover, the lateral ſurfaces of the nares are increaſed by the ſpiral windings of the *oſſa turbinata*[126]; the uppermoſt of which are ſmall turns or folds of a ſpiral figure from the upper part of the os cribroſum. The middle fold belongs to the ſame, ſomewhat oblong like a ſhell, internally convex, externally concave, riſing into an edge on each ſide; all over rough with little ſinuoſities or excavations, and inwardly filled with ſpungy cells or receſſes; the whole being ſuſpended in a tranſverſe poſition, and ſupported by particular eminences in the bones of the palate and upper jaw. The lowermoſt turbina, ſomewhat like the middle ones, do like them reſemble the figure of a limpet ſhell, but longer; for the moſt part divided from the former, but ſometimes conjoined by a bony plate, which is moſt frequently of a membranous nature. This bony appendix, being extended upwards in a ſquare form, ſerves to complete the maxillary ſinus.

CCCCLXI. From hence the cavity of the nares is enlarged or dilated by various ſinuſes, which are a ſort of receſſes or appendages to the whole. And firſt, the frontal or uppermoſt ſinuſes, which are not always preſent, are of an irregular figure[127], intercepted betwixt the anterior and poſterior plate of the frontal bone, where it forms the ſuperciliary protuberances; and theſe, being not round in a fœtus, ſeem to ariſe from the action of the corrugator and other muſcles, which draw the anterior plate of this bone outward, ſo as to increaſe the diploë into large cells, in the ſame manner as we obſerve in the maſtoide proceſs. Theſe open in the upper part of the nares into the interior cell of the os papyraceum. There are inſtances of their being totally wanting, and growing after the birth.

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[126] The oſſa turbinata are commonly counted three; but if indeed we take any turning of the bone in the cavity of the noſtrils for a bone, their number muſt be increaſed to four, and ſeveral paſſages alſo are formed.

[127] The frontal ſinuſes ſometimes grow to a remarkable ſize. Laſt winter, in a male ſubject, they extended not only over all the orbit, that the plates of the orbitary proceſs of the os frontis were diſtended two or three lines; but what is ſtill more ſurpriſing, they penetrated into the alæ minores of the ſphenoid bone, and communicated with the ſphenoidal ſinuſes by a diſtinct canal going to the inner ſide of the foramen opticum. In theſe ſinuſes, worms of various kinds lodge; which I aſſert, partly from my own experience, in which I ſaw in a boy of thirteen years of age ſome lumbrici, and leeches in dogs, which is likewiſe proved by other learned men.

CCCCLXII. In the ſecond place come the *ethmoidal ſinuſes;* which are four or more on each ſide, in the outer part of the os cribroſum, like the cells of an honey-comb; completed above by the cellular middle part of the os frontis, and before by the os unguis; behind, by the bone of the palate and ſphenoid bone; from whence they open by many ſmall tubes, placed one above another in a tranſverſe poſition, into the upper part of the nares. With theſe are continuous the cells in the pavement or bottom of the *orbit*, and thoſe engraved in the os planum and maxillare are continued from them outward. In a third place, this ſinus is contiguous on each ſide with the cavity or *ſinus of the multiform bone*, extending largely on each ſide towards the os cribroſum and palatinum, which is itſelf formed in a dry preparation, by the cartilage of large extent in the fœtus, and by a ſolid bone, which gradually widens under the ſella turcica, with an ample cell either ſingle or divided; and opening forward by its aperture or foramen, into the ſuperior part of the meatus narium.

CCCCLXIII. The laſt, lowermoſt, and biggeſt ſinus, which in a fœtus is inconſiderable, but in an adult very large, is that formed in the bone of the *upper jaw* by ſeveral thin bony plates. The opening of this into the noſe is betwixt the os unguis bone of the palate and the proper lamella or plate which accedes to it from the bottom of the os turbintatum. Which opening is ſo much leſſened by the ſurrounding membranes, as to form only a moderate round aperture in the ſpace betwixt the middle and bottom of the os ſpongioſum. But it likewiſe ſends forth an hollow appendix, tending forwards, under the orbits which the os planum, unguis, and papyraceum complete, communicating likewiſe with the ethmoidal cells, and open behind the oſtium lachrymale.

CCCCLXIV. The nerves of the noſe, being almoſt naked, required a defence from the air, which is continually drawn through the noſtrils, and blown out again by the uſe of reſpiration. Nature has therefore ſupplied this part, which is the organ of ſmelling, with a thick inſipid mucus, very fluid in its firſt ſeparation, and not at all ſaline, but, by the air condenſing into a thick dry cruſt, more conſiſtent here than in other parts of the body. By this mucus the nerves are defended from drying and from pain. It is poured out from many ſmall arteries of the noſtrils; and depoſited partly into numerous cylindrical ducts, and partly into round viſible cryptæ or cells ſcattered all over the noſtrils. The ſame flows out all over the ſurface of the olfactory membrane, which is therewith anointed on all ſides. In the ſeptum runs down forward a long ſinus to a conſiderable length, which is common to many muciferous pores: this mucus is accumulated in the night-time; but in the day expelled by blowing the noſe, or ſometimes more powerfully by ſneezing; and may offend by its exceſs or tenuity, or irritate by too great thickneſs the very ſenſible nerves, from whence a ſneezing is excited for its removal. But the ſinuſes of this part, which abound with mucus, are this way variouſly evacuated, agreeable to the different poſtures of the body; by which always ſome of them are at liberty to free themſelves, whether the head be erect, or inclined forward, or laterally; yet ſo, that generally the maxillary and ſphenoidal ſinuſes are more difficultly emptied than the reſt. Moreover, the tears deſcend, by a channel proper to themſelves, into the cavity of the noſe, by which they moiſten and dilute the mucus.

CCCCLXV. To the extreme parts of the nares or organs of ſmelling is prefixed the noſe; lined inwardly with a membrane of the ſame nature; and compoſed of two bones, and uſually ſix cartilages, two of which are continued together into the middle ſeptum, (CCCCLIX.). Theſe cartilages render the noſe moveable by its proper muſcles, ſo as to be raiſed and dilated by a muſcle common to the upper lip, and to be contracted together into a narrow compaſs by the proper depreſſor and compreſſor muſcle pulling down the ſeptum. Thus we ſee that this organ projects, like an engine in the air, for the reception of ſmells, and may be dilated in proportion to the quantity of inhaled air, and again contracted, when it is expelled in the ſame abundance.

CCCCLXVI. The air, therefore, filled with the ſubtle and inviſible effluvia of bodies, conſiſting of their volatile, oily, and ſaline particles, is, by the powers of reſpiration (CCLXV), urged through the noſe, ſo as to apply the ſaid particles to the almoſt naked and conſtantly ſoft olfactory nerves, in which a kind of feeling is excited, which we call *ſmelling*: and by this ſenſe we diſtinguiſh the ſeveral kinds of oils, ſalts, and other matters, difficultly reducible to claſſes, which hereby we perceive indiſtinctly; whence they are difficultly recalled to memory, though the odours already eſtabliſhed are ſufficient enough for our purpoſes. This ſenſe ſerves to admoniſh us of any pernicious putrefaction; of any violent acrimony; or of a mild, ſoapy, and uſeful diſpoſition in bodies. And as ſalt, joined with an oil, is the object of taſte; ſo a volatile oil, aided with ſalts, ſerves to excite ſmells: whence the affinity of the two ſenſes, which conjunctly aſſiſt and move each other, may be eaſily underſtood. But volatile particles chiefly are diſtinguiſhed by ſmell, and fixed ones by the taſte; perhaps becauſe the thick mucous cuticle, ſpread over the tongue, intercepts the action of the more ſubtle ſaline effluvia from acting upon the taſte, which yet eaſily affect the ſofter and leſs covered nerves of the internal noſe. We are ignorant of the reaſon why ſome ſmells pleaſe, and others diſpleaſe; perhaps cuſtom may have ſome effect in this caſe.

CCCCLXVII. Smells have a very ſtrong action, but of ſhort continuance; becauſe they are applied immediately, by the moſt minute particles, to nerves which are very near to the brain itſelf, and almoſt naked; from thence too proceeds the force of poiſonous vapours, and the refreſhment from agreeable odours, by which ſome perſons are effectually recalled to themſelves out of a dead ſwoon, or even after drowning. From hence comes that violent ſneezing, which often ariſes from acrid particles; and a looſeneſs or purging of the bowels, from the ſmell of ſome medicines, with the power of particular antipathies. From hence is derived the pernicious effects of exceſſive ſneezing, more eſpecially blindneſs, from the near conſent or ſociety of the nerves. But amongſt the various parts of the noſe, the ſeptum, and more eſpecially the os turbinatum, have a conſiderable ſhare in the organ of ſmelling: ſince theſe are parts multiplied in quick ſcented animals, ſo as to form beautiful ſpires in hounds and other quadrupeds; and in fiſh, who ſmell by water, they are formed like the teeth of a comb, in an elegant manner.

CHAP. XVI.

Of HEARING.

CCCCLXVIII. AS the ſenſe of ſmelling diſtinguiſhes the ſmall bodies which float in the air, ſo that of hearing perceives the elaſtic tremors or impulſions of the air itſelf. Therefore, we obſerve the ſenſitive organ of the ear to be compoſed in a different manner from that of any of the other ſenſes; as it is made up, for the moſt part, either of hard bones or elaſtic cartilages and membranes, which are the moſt exquiſitely enabled to receive and communicate the neceſſary tremors.

CCCCLXIX. The external part of this organ, called the *auricle* or outer ear, is a cartilaginous funnel, connected, but with a ſort of mobility, before and behind, to the bones of the temple, by means of a ſtrong cellular plate, and likewiſe by its own proper ligaments and muſcles; but the mobility of this part is diminiſhed by cuſtom. This cartilage is of a very compound figure; in general of a kind of oval figure, yet marked with ſpirals ſtanding up, and hollows interpoſed, to which other hollows and ridges correſpond in the oppoſite ſurface. The outer eminence, called *helix*, begins above by a looſe tape, is carried round at liberty about the edge of the upper part of the cartilage, upon the poſterior ſide of which it terminates in the ſame looſe manner. Within the body of the cartilage, ſurrounded by the former, ariſes a bifurcated eminence, meeting together in one, called the *anthelix*, which terminates in a ſmall and ſhort tongue called the *antitragus*. The remaining part of the ear, called the *concha* or ſhell, is, before, hollow; behind, convex; growing gradually deeper, with a crooked line or ridge running through its middle, under the denomination of the concha, which is immediately joined with the meatus auditorius; before which ſtands a round moveable appendix of the cartilage, as a defence, called the *tragus*.

CCCCLXX. This whole cartilaginous body of the outer ear is only ſurrounded by a thin ſkin, and an empty cellular ſubſtance; it is repleniſhed with many ſebaceous glandules, which ſupply an ointment. This part is governed or directed by certain muſcles, which generally loſe their uſe and action, from the cuſtom of binding the head in children, which we are otherwiſe to ſuppoſe they were deſigned by nature to perform. The uppermoſt of theſe muſcles ariſes thin from the frontal and from the aponeuroſis of the cranium; whence it is broadly ſpread over the aponeuroſis of the temporal muſcle, and is inſerted into the anthelix, or neighbouring helix, at the ſide of the anonymous cavity. The poſterior muſcles, which are two or three, more or leſs, are more robuſt than the former in a tranſverſe poſition; and, ariſing from the ſame aponeuroſis, are inſerted into the convex part of the concha near the maſtoidal bone; the cavity of which concha they, doubtleſs, are deſigned to open or enlarge. The anterior muſcle is one of the leaſt, which, being ſpread upon the aponeuroſis of the temporal, is inſerted almoſt tranſverſely into the origin of the helix and neighbouring concha. But the leſſer muſcular portions, which, though ſhort, and not very conſpicuous, look of a red colour, are probably of uſe to make ſome change in the figure of this part. The tranſverſe muſcle of the outer ear, which, for a long way, conjoins the helix with the anthelix, ſerves to open the auricle. The antitragic muſcle, deſcending from the root of the anthelix to the antitragus, ſerves to widen the entrance of the concha. The tragicus, which lies upon the tragus, opens the entrance to the auditory paſſage; and the ſmall muſcle of the larger notch or inciſure, that lies betwixt the two cartilages of the auditory paſſage, forming the tragus and antitragus, ſerves to bring them nearer together, and to render the meatus itſelf more tenſe and elaſtic. The remaining muſcles, the longer or larger, and the leſſer of the helix, have hardly any great uſe; unleſs it be to tighten or brace up the cartilages whenever we attend or liſten to the hearing of weak ſounds; and, by drawing together the cartilages, they likewiſe render the auditory paſſage more firm.

CCCCLXXI. To the concha is connected the *meatus auditorius*, ſomewhat of a round compreſſed figure, leſſening as it bends inward; for a conſiderable part bony, and bent forward in its middle. But, in its anterior and outer part, it is, in ſome meaſure, made up by three imperfect rings, ariſing from the concha and tragus, and united together, and to the bone itſelf, by intermediate fleſh, membrane, and cartilage. Upward and backward, the meatus is completed by a mere membrane. This is the ſtate of it in adult perſons; for, in the fœtus and new-born infants, the meatus is wholly cartilage, and becomes afterwards, in part, a bone by degrees.

CCCCLXXII. Through the auditory paſſage are continued the cuticle and true ſkin, gradually extenuated and exactly ſtretched over the ſurface of the bone, by which it is rendered extremely ſenſible of any itching pleaſure or pain; and, being repleniſhed with irritable hairs, is by them admoniſhed of any ſordes or wax abounding, and guarding from the entrance of ſmall inſects. But, in the cellular ſubſtance under the ſkin, which is here more firm, and makes up the greater part of the membrane (CCCCLXXI.), in a ſort of reticular manner, are ſeated numberleſs round follicles or cells of a yellow colour, which pour out their contents by ſhort ducts into the cavity of the auditory paſſage; at firſt of an oily conſiſtence, but afterwards it becomes more thick, bitter, and inflammable like wax. This liniment defends the ſenſible ſkin and membrane of the tympanum from injuries of the air, and keeps out or catches any ſmall inſects; but, when accumulated in too great abundance in thoſe who are ſlothful or uncleanly, it may be the cauſe of deafneſs, or a difficulty of hearing.

CCCCLXXIII. Into this funnel of the ear the ſonorous waves of the air flow, which, from principles of mechanics, it muſt of courſe collect together. The elaſtic air only receives ſonorous tremors or impulſions; and transfers them, either alone or principally, much after the ſame manner as we ſee water, without air, transfer any impulſe that is given to it[128]. From hence, the ſound is increaſed in air that is condenſed, and is loſt in a veſſel emptied of its air. But the medium receives theſe tremors, either from ſome body ſtriking againſt it, or from the air itſelf colliding againſt another body, or laſtly from the colliſion of two bodies againſt each other in the air. But the body which produces ſound, ought to tremble or vibrate in all, even the leaſt of its particles, ſo as to form alternate arches riſing up from the former ſtraight ſurface, and returning beyond the ſame; the curve line of the ſame exceeding that of the ſounding body. From ſuch a tremor, the contiguous air is beat into waves, whereby the parts of the air that lie outermoſt are compreſſed and fly back again ſo ſoon as their elaſticity gets over the impulſe; whence the air flies again towards the ſonorous body, where it is now more looſe and rarefied, to be there again compreſſed by impulſion; and in the ſame manner the anterior and outer portion of air, ſurrounding that which is impelled, is, by the action of the latter, compreſſed and removed farther from the trembling body, yet ſo as to return again in its proper time by the force of elaſticity, driving its contents to the tremulous body for the exciting of a new wave. Theſe oſcillations or impulſions of the air are required to ſucceed each other with a certain velocity; and, in order to render them audible, they muſt not be fewer than 30 in a ſecond of time.

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[128] That water communicates the ſonorous undulations, divers ſeem to prove; becauſe, when under water, they hear the ſound and voices of thoſe at the ſhore: and it is now beyond doubt, from the power of hearing which fiſhes poſſeſs. The indefatigable inveſtigator of nature, Lyonnet, is of opinion that inſects hear. Long ago Ariſtotle and Klein aſſerted the power of hearing poſſeſſed by fiſhes: Nollet agreed with them, but Camper has confirmed the aſſertion, viz. they have a kind of tympanum, in which there is a ſmall bone, a certain figure of a concha, receiving a nerve: they alſo have ſemicircular cartilaginous canals, through which in like manner nerves are diſtributed.

CCCCLXXIV. Acute ſounds are, in general, yielded from bodies that are hard, brittle, and violently ſhook or ſtruck; but grave ſounds are from the contrary. Thoſe ſounds in general are called *acute*, which are produced from more numerous tremors in an equal time; and thoſe *obtuſe*, which are produced from few tremors. As to any medium betwixt acute and grave ſounds, there is none but what is arbitrary. Cords, or other bodies, that yield the ſame number of vibrations in a given time, are ſaid to be *uniſon;* as thoſe which make double the number of oſcillations in that time, are ſaid to yield a tone that is an octave or eight notes higher; and other proportions betwixt the numbers of the vibrations have different names aſſigned to them. The ſhorter cords produce ſharper tones, and the reverſe, in a proportion directly as their lengths; as thoſe which are more ſtretched afford ſharper ſounds in a ſubduplicate proportion to their tenuity, or to the weights or powers by which they are ſtretched. Experiments to this purpoſe are very eaſily made with a monochord, or a ſeries of cords ſtretched with weights[129].

CCCCLXXV. The ſound, thus produced, whether acute or grave, ſtrong or weak, is carried through the air with a celerity equal to about 1038 Paris feet in a ſecond, and that with an uniform velocity, without abating in the larger diſtances. But a contrary wind, cauſing the vibrations to extend more ſlowly, retards the progreſſion of ſound about $\frac{1}{12}$ of its velocity. So likewiſe denſity and dryneſs of the air increaſe the ſound, as a rarefaction and moiſture of the air leſſen it. Hence, in ſummer time, ſounds move ſwifter; and in Guinea, it has been obſerved to paſs at the rate of 1098 Pariſian feet in one ſecond of time.

CCCCLXXVI. The ſound, thus every way extended, meets with certain particles in all adjacent bodies, even in water and mercury, to which it communicates ſimilar tremors or vibrations, not only ſuch as are in uniſon with the original tone, and which yield a ſound in a more particular manner ſenſible; but alſo it excites tremors leſs ſenſibly, even in the other parts of bodies, which vibrate in the various proportions of the ſcale. From hence it is, that every ſound which we hear, is a mixture of the original tone, produced by the trembling body, in conjunction with ſecondary tones generated from the elaſtic tremors of the ſurrounding bodies. The ſtrength of ſound is increaſed, if one audible or primary tone follows the other ſo cloſely, that their ſucceſſion cannot be diſtinguiſhed by the ear; but if they follow each other ſo ſlowly as to be diſtinguiſhable by the ear, they produce an echo; but to produce this requires an interval of ſix thirds of a ſecond of time, or the diſtance of 55 feet betwixt the reflecting or echoing body and the ear.

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[129] The doctrine of muſic undoubtedly is to be accounted among the chief proofs of human induſtry. It has recommended itſelf, not by the art by which it has been cultivated over all Europe, and particularly at Naples, but likewiſe by its effects upon animal bodies; ſo that almoſt any affections of the mind may be produced by it, and diſeaſes themſelves, particularly of the nervous kind, may be cured. Albrecht and Roger have given an abridgment of this art; but theories of this doctrine, its foundation, and conjectures upon it, have been propoſed by ſeveral celebrated perſons; ſuch as Euler, Rameau, La Grange, Burney, and ſeveral others.

CCCCLXXVII. Sounds, being elaſtic, are reflected from hard bodies in angles equal to thoſe of their incidence. But the ſame ſound, uſhered into the open air, and dilating through an immenſe ſphere, grows proportionably weaker: but if it be uſhered through a tube, in a cylindrical ſhape, the ſtrength of it is more confined together; or elſe, by being collected into the focus of a parabola or ellipſis, it becomes increaſed, as we obſerve in ſpeaking-trumpets, from which the voice goes out parallel to the focus of the parabola, without ſcattering the ſonorous rays.

CCCCLXXVIII. Therefore the ſonorous waves of the elaſtic air, being driven into the cartilaginous funnel of our ear, which is naturally inclined forward and outward in an high ſituation, are repelled and collected together, by alternate reflections from its elaſtic ſides, into the cavity of the concha, from whence it proceeds through the auditory paſſage, with a force ſo much ſtronger as the ſurface of the outer ear is larger than the light or ſection of the auditory paſſage. Through this paſſage, however cylindrical, the ſame force is continued entire forward, and increaſed by new reſonances, excited from the percuſſion of the elaſtic cartilages and hard bones, ſo as to mix imperceptibly with the primitive ſound.

CCCCLXXIX. Moreover, the bottom or end of the ſaid auditory paſſage is terminated internally by a thin membrane, called the *membrana tympani;* which, in adults, is of a roundiſh figure, and placed with an obliquity; but ſo that from its upper appendix it projects inward like a ſhield, whilſt the part which lies above its middle projects into the cavity of the meatus like a ſhield. This membrane of the tympanum is compoſed of ſeveral plates; the firſt or outermoſt of which is white and mucous; the other is a true ſkin, continued from the membrane of the meatus, and of a vaſcular texture; the third is a dry, rattling, ſplendid, and pellucid membrane or plate, without blood-veſſels; and the innermoſt is the vaſcular perioſteum of the auditory paſſage and tympanum, with a tender cellular texture lying between. This membarne is not naturally perforated with any opening, ſo far as I have been able to diſcover, and the tranſmiſſion of ſmoke is fabulous. It is conſtantly ſo ſtretched in the ſulcus or groove of the bony ring, in which it is contained, proper to the fœtus, and after the birth coaleſcing with the reſt of the os petroſum, that there is no part of the human body to be found more tenſe or more tremulous than this. Upon the ſurface of this membrane, and more eſpecially upon its conical cavity pointing inward, the ſonorous waves ſtrike, after they have received their laſt reflections from the auditory paſſage, by which the elaſtic fabric of this membrane is forced into oſcillation.

CCCCLXXX. This membrane is ſtretched over a cavity of the os petroſum, called the *tympanum;* which is, for the moſt part, of a roundiſh figure, but not regularly ſo; being divided in its middle into two by a promontory, and in the adult is increaſed backward by the cells of the maſtoide bone, which are abſent in the fœtus. But alſo, in its upper and anterior and poſterior part, the tympanum has hollow cells, and is lined with a vaſcular membrane, receiving ſmall branches from the internal carotid, and from a branch of the artery of the dura mater, which laſt paſſes thro' a fiſſure in the aqueduct, and it has others from the external arteries of the tympanum and from the ſtylomaſtoidea. It is commonly full of a mucus, poured into it from the Euſtachian tube, and is divided by various membranes into a kind of cells, namely, by productions of the perioſteum to the little bones.

CCCCLXXXI. Within this cavity, three of the larger *bones of hearing*, together with a fourth which is leſs, are ſuſpended moveably. And firſt, the *malleus* or hammer lies with its upper round head reſting upon the concavity of the tympanum, from whence the handle of it is extended down, along the membrane of the tympanum, betwixt the plates of it: having reached as low as the middle of the membrane, it terminates by a very cloſe coheſion, with a broad extremity a little incurvated outwards. The ſame bone is, moreover, connected and ſuſtained by a peculiar ligament of its own, joining it to the longer leg of the incus; and another membrane ſerves as a ſecurity near the longer proceſs of the malleus. This bone drives outwards the membrane of the tympanum, which is ſpread over the ſhorter and conical proceſs of its handle. From the ſame place of this bone a broad, long, and flat proceſs, goes out forward into a ſulcus of the tube. It is articulated with the incus by two heads, having protuberant lines with a ſulcus in the middle, and all of them oblique.

CCCCLXXXII. In the malleus are commonly deſcribed three muſcles: the firſt and internal of which, called *tenſor tympani*, being the largeſt, is lodged in a particular groove within the tube, with which it proceeds parallel; and, riſing from the proceſs of the multiform bone between the paſſage of the cerebral carotid and the hole of the artery of the dura mater, bending round a pully, is inſerted by its tendon reflected outward and downward into the beginning of the handle. The *ſecond* muſcle ariſes from a ſulcus in the ſame tube, but externally ſhorter than the former, and carried back almoſt in the ſame manner, but without being reflected: it adheres by a conſiderable extent to the longer proceſs; and the ſame is ſuſpected to be but little different from the red pulpy membrane. The *third* muſcle of the malleus, which ariſes from the auditory paſſage, paſſes through a notch in the broken or interrupted ring of the tympanum, and is inſerted juſt by the ſhorter proceſs into the malleus; and this, which is by ſome ſaid to relax the membrane of the tympanum, has never been ſeen with ſufficient certainty neither by myſelf, nor by the moſt eminent anatomiſts. For the reſt, by means of the tenſor of the malleus, the membrane of the tympanum is diſpoſed for the hearing of weak ſounds; as the other muſcle ſerves to moderate in too violent ſounds, by drawing the malleus from the incus; by which therefore the propagation of the ſonorous tremors is interrupted. If the membrane of the tympanum be broke, or the bones of hearing diſlocated, the perſon becomes at firſt hard of hearing, and afterwards perfectly deaf; this part being the ſeat of that ſlight hearing which is propagated through the bones of the ſkull.

CCCCLXXXIII. The malleus returns the tremors impreſſed upon the membrane of the tympanum to the incus, which is a ſhort thick little bone, articulated with the former behind by a broad ſurface, with two ſulci and a middle eminence. The ſhorter leg of this bone, whoſe little body is bifurcated, being ſuſpended by a ligament, is held firm into a ſulcus proper to the bone. Another longer one deſcends parallel to the malleus; and, by a ſomewhat crooked extremity, is adapted to the fourth orbicular bone which it receives, convex on one ſide, flatter on the other, and reſting upon the ſtapes, to which its protuberances are imparted.

CCCCLXXXIV. The *ſtapes*, aptly enough ſo called from its figure, lies inclined, but more backward than forward, with a hollow head that receives the incus, from whence proceed two little crooked legs, the poſterior one of which is largeſt: but below, its oval baſis is occupied by an aperture of a correſponding figure, commonly called the *feneſtra ovalis*. Here the legs, which are ſulcated inwardly, are conjoined by a tenſe membrane affixed to the hollow baſis. This bone of the ſtapes is covered by its own muſcle, which being included in a bony papilla or caſe, ſends out a ſmall tendon, which is inſerted under the incus into the head of the ſtapes. Hence it ſeems to draw the ſtapes, that it may lie higher up, under the back part of the feneſtra ovalis, and paſs out of it before. Thus the nervous pulp of the veſtibulum is preſſed by the baſis of the ſtapes, and by the air of the tympanum. The whole courſe or ſeat of the ſtapes is ſeparated from the reſt of the tympanum, by a membrane proper to itſelf,

CCCCLXXXV. A ſmall roundiſh oval-ſhaped bone, here and there greatly excavated, is here fixed to the longer leg of the incus, and from thence goes to the ſmall head of the ſtapes.

CCCCLXXXVI. There are various channels which paſs out from the cavity of the tympanum. Above the two larger bones behind the poſterior leg of the incus, is a ſmall cell, a kind of appendix to the tympanum, of the figure of a gnomon. Behind that the ſmall cells begin in the os petroſum, above the mamillary proceſs. Below theſe, that proceſs is excavated in an adult by various ſmall caverns.

CCCCLXXXVII. From thence the proper canal, going out forwards from the anterior extremity of the tympanum, emerges from the bones lying between the os multiforme and the oſſa temporum; and is joined into a correſponding elliptical and diverging cone, partly membranous, and in part made up of cartilages of a variable ſtructure; it opens by a very ample elliptical aperture, turning inward and forward behind the nares, into the cavity of the fauces: it is lined with a porous membrane, full of cryptæ and mucous cells, continued from and like to the membrane of the nares. This is the *tube* which, by the action of the circumjacent muſcles, may be compreſſed and cloſed, and probably a little relaxed and opened again, by the circumflex muſcle of the moveable palate. By this canal the inſpired air enters into the tympanum to be changed or renewed, and the ſurrounding mucus of the little bones and other parts are this way depoſited: nor is it at all improbable, that the air enters by this tube, to ſupport the tympanum when it is preſſed inward by the more violent ſounds; for ſounds themſelves, received into the mouth, are this way conveyed to the organ of hearing.

In inſpiration, the air preſſes the membrane of the tympanum outward: and from thence proceeds that claſhing or whiſpering noiſe, by which the hearing is obſcured, when the mouth is held wide open in yawning; for then the air entering more abundantly through the cavity of the tube, to the tympanum, reſiſts the tremors of the external air.

CCCCLXXXVIII. Two other paſſages lead from the tympanum to the *labyrinth*, or innermoſt chamber of the ear[130]. And, again, the feneſtra ovalis (CCCCLXXXIV.) not covered by any membrane, leads into the *veſtibulum;* which is a round cavity, formed in a very hard part of the os petroſum, that lies near the inner part of the tympanum. In that cavity are three receſſes; of which the upper one is elliptical, the lower one circular, and the third like a furrow. There is a nervous pulp in the veſtibulum diſtinguiſhed from the parietal bone by the vapour ſurrounding it[131]. Into this open the five mouths of the three ſemicircular canals, the foramen ovale, and the paſſages of the nerves and arteries.

CCCCLXXXIX. In the fœtus, theſe are formed of a diſtinct hard ſhell, which being ſurrounded with a ſpungy bone, are lodged in a cavity of the os petroſum; which, in adults, is extremely hard, extended into ſegments ſomething larger than ſemicircles, which have an

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[130] There is almoſt no part of the human body ſooner acquires its perfect magnitude than the labyrinth of the internal ear: for in a fœtus of five months, it is almoſt of the ſame ſize as in an adult.

[131] All the internal cavity of the labyrinth is filled, not with vapours, but with true water. In 1771, I had two caſes of perſons who died through cold, in whom an icy ſtria could be perceived penetrating through the feneſtra ovalis, the ſtapes being driven out from the veſtibulum into the cavity of the tympanum. No perſon before Cotun, although Vieuſſens, Salzman, Valſalva, Morgagni, &c. had ſome knowledge of the ſubject, was really and fully acquainted with this water, which Caldan and Meckel have more fully confirmed. The whole cavity of the labyrinth, particularly of the veſtibulum, is filled with it: if you inject quickſilver, it is expelled; or by cold, it is converted into ice, exactly repreſenting the figure of the cavity: This is ſeen in ſeveral animals. It is ſecreted from the arteries, and thrown out by two ſmall canals, through which at leaſt mercury goes from the cavity of the labyrinth.

ample opening betwixt them. The larger poſterior and lower of theſe circles is perpendicular; alſo the middle and upper one is placed towards the perpendicular; but the outermoſt and leaſt is horizontal. The inner mouth or aperture of the uppermoſt of theſe meets with the upper opening of the poſterior ring, and both join into one.

CCCCXC. But the cochlea is a part ſtill more wonderful, ſeated in an inclined poſture within the anterior portion of the os petroſum. Into one part of this cavity opens the veſtibulum; and into the other the *feneſtra rotunda* of the tympanum [132], which is concealed behind a protuberance in the bottom of the tympanum. The cochlea itſelf is made up of a nucleus of bone, of a conical figure, with its apex inclined inward; divided by a middſe ſulcus, both through its baſis, and through its whole length; and perforated with innumerable ſmall foramina into the tubes, which are called *ſcalæ*, terminating in the middle of the ſecond ſpiral. About this nucleus are wrapt two turns and a half of a canal; which in the fœtus is made up of a diſtinct ſhell-like ſubſtance, peculiar to itſelf; and, in the adult, is united into one, with the adjacent bone: and this winding canal diminiſhes gradually in a conical figure, from the two forementioned openings towards the tip of the nucleus. It is bilocular, or made up of two apartments, divided by a partition called *lamella ſpiralis*. This, at its larger end, is bony, and extended out of the nucleus, at right angles, into a cavity; is ſtriated, and every way wrapt up by the internal perioſteum as in a capſule. Another external part hereto belonging, is a membrane, which likewiſe divides the canal: thus there are formed two diſtinct ſemicanals, called *ſcalæ*. The interior and poſterior of theſe canals begins from the feneſtra rotunda, where it is ſhut by a membrane, and is called the *ſcala tympani;* the other begins before, from the veſtibulum, from which it has its name. In the tip of the cochlea is formed a third cavity ſhaped like a funnel. Into this the ſpiral lamina terminates by a membranaceous extremity, but ſo that the funnel communicates with them by a ſmall hole on each ſide; but, in many bodies, it alſo communicates with the cavity of the bucket that is filled with the nerve.

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[132] It is now very clear to all from the obſervations and figure of Scarpa, although it was not known before.

CCCCXCI. The blood-veſſels of the outer ear come from the temporal or proper auricular branches; thoſe to the membrane of the tympanum are either from the temporal, from the ſtylo-maſtoideal, or from both; thoſe of the meatus auditorius come from the former; thoſe to the tympanum were deſcribed CCCCLXXX.; and the veſſels belonging to the veſtibulum, cochlea, and ſemicircular canals, are from the vertebrals and ſtylo-maſtoideals. The induſtry of late anatomiſts has diſcovered veſſels of a particular kind, proper for carrying back liquids from the veſtibulum into the tranſverſe ſinus, from the cochlea into the cavity of the ſkull.

CCCCXCII. It now remains that we deſcribe the nerves deſtined to the ſenſe of hearing, of which the principal is that called the *ſeventh* (CCCLVII.) This nerve enters into the internal auditory ſinus of the os petroſum, in the blind end of which it divides. The ſmaller part of the nerve is ſent upward, through the opening of a canal in the ſinus; whence paſſing tranſverſely, it is afterwards bent behind the tympanum. In this part deſcending, it gives off a branch through a peculiar channel to the tympanum, which aſcends betwixt the malleus and incus, and goes out of the tympanum, through a fiſſure behind the articulation of the lower jaw, afterwards inſerting itſelf into the nerve of the tongue (CCCCLVII.); the reaſon of which ſecret communication is obſcure, but ſerves to explain the conſent of the teeth ſet on edge by ſharp ſounds, a removal of their pain by burning the ear, &c. The reſt of the nerve, eſcaping by the ſides of the ſtyloide proceſs, is diſtributed through the external ear, the parotid gland, a large part of the the face, and upper part of the neck, both cutaneous and muſcular; and in the face forms numberleſs inoſculations, both betwixt its own branches, as well as with thoſe of the firſt, ſecond, third, and fifth pair; and it likewiſe communicates with the eighth pair, and the third cervical pair. But to the immediate organ of hearing it ſends either no branches, or at leaſt very ſmall ones. The outer ear again receives other nerves in its fore part from the third branch of the fifth pair, and in its back part to the ſecond and third of the cervicals.

CCCCXCIII. But the *ſoſt portion* of the auditory nerves ariſes larger, but more obſcure, from the fourth ventricle of the brain itſelf (CCCLVII.) and enters by very minute threads through exceeding ſmall holes of the inner auditory ſinus, which go in part to the veſtibulum, and in part to the ſurface of the cochlea. The branches in the veſtibulum form a pulp-like tender membrane[133], which is every way extended through the ſemicircular canals. The other part, entering the furrow of the cochlea, has an obſcure termination.

CCCCXCIV. With reſpect to the nerve which is diſtributed through the veſtibulum and ſemicircular canals, there is no doubt but it is ſtruck by the tremors of the external air, propagated to the ſtapes; from whence the tremors immediately paſs through the oval feneſtra, to preſs upon the naked pulp of the nerve. That part of the nerve which enters the cochlea is altogether obſcure in its termination. It is probable, that ſmall branches from thence paſs through the little foramina (CCCCXC.) to the perioſteum of the cochlea, and to the membranous part of the ſpiral partition. Do the tranſverſe nervous filaments paſs out from the nucleus of the cochlea, all the way ſucceſſively ſhorter through the ſpiral plates? Is it the organ of hearing? Theſe are queſtions, which we are yet hardly able to reſolve from anatomy; though this ſeems repugnant to the courſe which we obſerve nature takes in brute animals, in birds, and in fiſhes, who all hear very exquiſitely without any cochlea. However this may be in the human body, it is there probable, that the ſpiral plate, ſpread full of nerves, is agitated with tremors from the oſcillations of the membrane of the tympanum, by which the air in the cavity of the tympanum is agitated, ſo as to preſs the membrane of the round feneſtra, which again agitates the air contained in the cochlea.

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[133] The veſtibulum is divided by a certain proper membranaceous ſeptum into two parts, over which a great portion of the ſeventh pair is diſtributed: the reſt of it is diſtributed almoſt in the ſame manner over the cochlea as the optic ends in the retina.

CCCCXCV. The preceding conjecture is indeed elegant; ſince the ſpiral plates make up a triangle, ending in a ſhort point towards the tip, by which it may be conceived to contain an infinite number of nervous cords, continually ſhortening in their length; and by that means adapted to an harmonical uniſon or conſonance (CCCCLXXIV.) according to the variety of acute and grave ſounds, ſo as to tremble together at the ſame time with moſt of them; namely, the longeſt cords in the baſis of the cochlea with grave ſounds; and the ſhorteſt cords nearer the tip or apex, with the ſharper ſounds. Whether are ſounds perceived in the middle ſemicircular canals, when theſe alone are found in all claſſes of animals? Are they detained in theſe canals, in the cochlea, and by the membrane ſuſpended through the veſtibulum? This ſeems probably the caſe.

CCCCXCVI. From what has been ſaid, it appears, that the elaſtic waves or tremors of the air arrive thro' the outer ear and auditory paſſage, to the membrane of the tympanum; which being injured, and not repaired, the hearing is totally deſtroyed. This ſeems to be ſtretched, for hearing weak ſounds, by the muſcles of the malleus. From this membrane the ſound is conveyed through the ſmall bones to the veſtibulum; for theſe bones being deſtroyed, the hearing is again aboliſhed. The bony ſides of the veſtibulum, by their tremulation, agitate the ſmall quantity of aqueous fluid ſurrounding the nervous pulp. It ſeems to be ſtruck by the nervous pulp ſuſpended in the veſtibulum, and that tremor to be continued through the continuous pulp of the cochlea and ſemicircular canals. Of more than this we are not certain: but, by undoubted experiments, tremors, and even elaſtic ſounds, communicate themſelves by the internal Euſtachian tube, and through all the bones of the ſkull, ſo as to impreſs their force upon the auditory nerve.

CCCCXCVII. The diſtinction of ſounds, doubtleſs, proceeds from the celerity of the tremors excited in the hearing nerve, according as they ſucceed each other more ſwiftly or ſlowly, in a ſhort time; in order to which it is not neceſſary the mind ſhould number them; it is ſufficient that ſhe perceive their numbers to be different, and that this difference excites a variation in her thoughts and ideas thence ariſing. Whether the harmony or agreeableneſs of ſounds ariſes from the number of parts ſounding together in uniſon? and whether the mind, ignorant of herſelf, numbers the degrees of conſonance, ſo as to pleaſe herſelf in a majority of them? theſe are queſtions denied by the moſt expert muſicians, who make it appear, that there is an agreeableneſs, and that very conſiderable, in ſounds approaching the leaſt to a conſonance, and which lies in a proportion very difficult to determine. Why do ſounds often become too ſharp for the ear? Our auditory nerves ſeem to be ſtrained upon the ſpiral plates, in ſuch degrees as to be in danger of breaking, after the manner drinking-glaſſes may be broke by ſharp ſounds, and as the hearing is ſometimes almoſt loſt for a while by the violently ſhrill whiſtlings of the inhabitants of the Canary iſlands.

END OF VOLUME FIRST.

FIRST LINES

OF

PHYSIOLOGY,

BY THE CELEBRATED

BARON ALBERTUS HALLER, M.D. &c.

TRANSLATED FROM THE

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FIRST LINES

OF

PHYSIOLOGY.

CHAP. XVII.

Of the SIGHT.

CCCCXCVIII. AS the organ of hearing perceives the tremors of the air, ſo the ſight perceives thoſe of light: and as the firſt conſiſted chiefly of bony organs capable of making a reſonance; here, on the contrary, the greater part of the eye is compoſed of pellucid humours capable of refracting the more ſubtle medium of light: but the complexity of this organ was neceſſary for the defence of its tender parts, and from the diverſity of the ſeveral humours to be contained each in their proper integuments.

CCCCXCIX. Outwardly, a defence is afforded to this organ by the eye-brow or *ſupercilium*, which is a protuberance of the ſkin ſuſtained by muſcles, at the bottom of the forehead, full of thick hairs, lying over one another like the tiles of a houſe; and capable of being pulled down by the action of the frontal, corrugator, and orbicular muſcles, ſo as to afford a ſhade to the eye in too ſtrong a light. After this office is finiſhed, the eye-brow is raiſed again, by the inſertion of the frontal muſcle, thin and fleſhy, immediately under the continuous ſkin, faſtened to the cellular membrane of the ſkull, which is of a ſhining ſubſtance, and not far different from the nature of an aponeuroſis, which, being, of a long quadrangular figure, is drawn backward by the occipital muſcle. A depreſſion of the eye-brow ſerves alſo to expreſs concern of the mind; as an elevation of it denotes the mind to be in a ſerene quiet ſtate. This guard alſo conduces to throw off the ſweat and retained duſt, or the inſects which might fall into the eye.

D. The *eye-lids*, or palpebræ, are placed ſtill nearer guards to the eye. Here the folds of the ſkin, which are thinly extended, from that of the face, run out in a conſiderable length, and are reflected back with the cellular ſubſtance interpoſed betwixt the outer and inner plate; the latter of which becomes then a thin vaſcular membrane, and therefore of a red colour, extended before the globe of the eye, and ſpread in its foremoſt part upon the ſclerotica, under the denomination of *conjunctiva tunica*. This production of the ſkin is every where covered by another of the cuticle, even where it is cloſely conjoined with the cornea. The upper eye-lid is larger and more moveable: the lower is ſmaller, and rather obſequious to the motion of the other parts, than moved by any particular forces of its own. The *nerves*, which give ſenſibility to the eye-lids, are numerous, from the firſt branch of the fifth pair, and likewiſe from the ſecond, and from the hard branch of the ſeventh pair; they abound with *arteries* from the ophthalmics, and from the branches of the temporals, internal maxillaries, infra-orbitals, and others of the face.

DI. That the eye-lids might ſhut together more exactly, they have each of them a cartilaginous arch, called *tarſus*, upon their margins, which meet together.

ther. It is ſlender, of a lunar figure, extenuated outward, and ſerves to hinder the eye-lid from falling into wrinkles while it is elevated or depreſſed. The elevation of the upper eye-lid is performed by a muſcle ariſing from the involucrum of the optic nerve gradually ſpreading, and extended by its expanſion to the tarſus. This elevator is conſiderably aſſiſted in its action by the frontalis, and by various connections with the orbicularis drawn up or dilated by the former. The upper eye-lid depreſſed by the *orbicularis* muſcle; which is broad and thinly ſpread round the orbit, under the ſkin of the eye-lids, to each angle of the eye, which ſerve as fixed points to this muſcle; and it adheres to the os frontis, where that bone joins the upper jaw, and then its fibres are inſerted into the os frontis and neareſt parts of the upper jaw. The ſame muſcle ſerves to elevate the lower eye-lid, and covers the eye in ſuch a manner that no duſt or light can enter it in ſleep. The lower eye-lid is depreſſed by a double portion of fibres, inſerted into the upper-lip.

DII. Finally, that the protuberant margins of the eye-lids might not injuriouſly beat againſt each other, the *cilia* or rails of hair are placed ſpreading outwards, in a row, from the edges of the eye-lids, of different lengths, which by croſſing each other make a blind or ſhade. Theſe are of uſe in more diſtinct viſion, by excluding the extraneous rays, when we require a diſtinct repreſentation of any object.

DIII. That the eye-lids rubbing againſt each other might not grow together, they are ſupplied with a row of *ſebaceous glandules*, firſt noticed by Meibomius; namely, about thirty little gut-like cells or more in each eye-lid; placed in general according to the length of the lid, without ever branching, but compoſed of peculiar blind ſinuſes, which end at laſt in one larger ſerpentine duct, opening by a mouth in the margin of the eye-lid itſelf. Theſe diſcharge a ſoft liniment, which mixes and waſhes off with the tears.

DIV. But the perpetual attrition of the eye-lids aſcending and deſcending againſt the globe of the eye, is prevented by the diſtilling humour called *tears;* which preſerve alſo the tenderneſs of the membranes and of the cornea, and ſerve to waſh out any inſects or other ſharp corpuſcles. Theſe form a ſaline pellucid liquor that may be evaporated, and never ceaſes to be poured over the anterior ſurface of the eye; but never runs over the cheeks, unleſs collected together in a larger quantity from ſome cauſe. This liquor is exhaled partly from the arteries of the conjunctiva, as we ſee from an imitation of nature by injecting water: and it is in part believed to proceed from a gland ſeated in a receſs of the orbit of the os frontis, ſomewhat hard, and of the conglomerate kind; intermixed with fat, and painted with many blood-veſſels from the ophthalmics and internal maxillaries; and interſperſed with many ſmall nerves ariſing from a peculiar branch of the firſt trunk of the fifth pair.

DV. From this lachrymal glandule in horned cattle deſcend three, four, or more viſible ducts, which open on the inner ſide of the conjunctiva, upon the eye-lid. In man thoſe ducts are lately found out, according to credible authors [134]. The ſeparation of the tears is increaſed by the more frequent contraction of the orbicular muſcle, either from irritation, or ſome ſorrowful paſſion, by which means the tears are urged over the whole ſurface of the eye and conjunctiva, which they waſh.

DVI. After the tears have performed their office, ſome part of them flying off into the air, the reſt, that they might not offend by their quantity, are propelled by the orbicular muſcle towards its origination next the noſe, to a part which is the loweſt of the palpebral margins; which not being ſurrounded by the tarſus, does therefore not meet exactly together. Here a *caruncle* full of ſebaceous hairy follicles, of an oblong figure, interpoſes and ſeparates the meeting of the eye-lids, at the ſame time furniſhing a liniment to thoſe parts which have none of the Meibomian ducts. Before this part is extended a ſmall portion, like a little eye-lid; which, deſcending perpendicularly, joins the true eye-lids, and is larger in beaſts than in men: but at the beginning of this ſpace, betwixt the eye-lids, in which the tears are collected, both in the upper and lower margin, a little papilla ſtands out, having each of them one opening, ſurrounded by callous fleſh, which are perpetually open, unleſs when convulſively cloſed. This opening, which is called the *punctum lachrymale*, drinks up the tears from the ſinus in which they are collected; and this partly by tubular attraction, and partly by impulſe from the orbicular muſcle. If theſe points or openings are obſtructed, the tears run over and excoriate the cheek.

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[134] If I followed the method of the celebrated Monro and Hunter, I could with a ſmall ſyphon make canals viſible in three places, coming from the inner ſide of the palpebræ into the gland.

DVII. From both points proceeds a ſmall duct, both from the upper and the lower eye-lid, much wider than the opening itſelf, but thin, and included in the ſkin; one of which goes downward above the caruncle, and the other goes more tranſverſely inward and under it: theſe both join together, and are inſerted by two mouths near the uppermoſt part of the *lachrymal ſac:* thus it is called a cavity, formed in the os unguis and upper jaw, lined with a membrane, which is at firſt cellular, but harder, and as it were of the nature of an aponeuroſis; then by another red and pulpy one, continued from the membrane of the nares, pervious to the exhaling dew, and ſomewhat of an oval figure. From the ſame ſacculus is continued a duct, which deſcends a little backward into the nares, opening there by an oblique oblong aperture at the bottom of the meatus, covered by the lower os ſpongioſum, Through this paſſage the ſuperfluous tears deſcend into the noſe, which they in part moiſten (CCCCLXIV.) A muſcle is by ſome aſcribed to this ſac; but it is not yet ſufficiently confirmed[135].

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[135] The famous Janin has lately propoſed an ingenious conjecture concerning the road of the tears, comparing the lachrymal ſac to the bladder

DVIII. The globe of the *eye*, compreſſed before, but longer than it is broad, is ſeated in the cavity of a bony orbit, which is almoſt of a conical figure, made up by ſeven bones which are in the back part; and on the inner-ſide perforated or interrupted by larger fiſſures, from whence the bones, widening forward, defend the cavity on all ſides. But as this is larger than the eye itſelf, the exceſs is on all ſides occupied by a very ſoft fat, ſurrounding the globe of the eye, that it may both fill and have a free motion within the orbit.

DIX. The eye begins from a conſiderable nerve, by the expanſion of whoſe coats thoſe of the eye itſelf are compoſed[136]. The origin of this optical nerve we have already deſcribed (CCCLVII.) Its progreſs is acroſs the crus of the brain, where it joins with its fellow nerve from the other ſide, and coheres therewith for a conſiderable length by a large portion of medullary ſubſtance; ſo that the right goes to the right eye, and the left to the left eye, yet not without ſome conjunction of both medullary ſubſtances. The nerve, therefore, thus enters the orbit a little inflected, of a figure ſomewhat round, but compreſſed; and is inſerted into the globe of the eye, not in the middle, but a little nearer to the noſe.

DX. The nerve having reached the eye, depoſites the inner plate of its dura mater, which it received in the opening of the ſphenoidal bone: and this being expanded and rendered thicker, makes up the firſt coat of the eye, called *ſclerotica*. The other outer plate of the dura

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bladder of urine, which retains the urine for any time, till it is thrown out, the ſphinctre being relaxed. He therefore aſcribes a ſimilar ſphinctre to the naſal canal, which is ſometimes ſhut, and again relaxed, that the tears collected in the ſack may run out through the noſtrils. The phenomena of the excretion of the tears, the tighter conſtriction which ſometimes ſhuts up the canal, and its folded ſtructure, render this opinion probable enough, although diſſection has not yet ſhown me any muſcular fibres.

[136] A more accurate anatomy now explodes this ancient error; for none of the tunics of the eye, the retina excepted, into which the optic is evidently changed, ariſes from the tunics ſurrounding the medulla of the nerve.

dura mater, receding from the former, makes up the perioſteum of the orbit: but the pia mater, which is in this nerve very diſtinct and full of veſſels, expands itſelf as before, ſo as to form a thin dark-coloured lining to the ſclerotica. The remaining inner medullary part of the nerve, continued from the brain, but divided into filaments by the cellular ſubſtance, is contracted into a depreſſed white conical papilla; after which it is again expanded upon the inner membrane of the eye, ſo as to form the *retina*.

DXI. The *ſcelerotica* is in general white, tough, and furniſhed with few veſſels, reſembling the nature of the cutis or ſkin, of a figure completely enough globular, but compreſſed or flattened before, and of a greater thickneſs backward. To the fore-part of this globe, cut off circularly, is prefixed obliquely a portion of a more convex but leſs ſphere; pellucid[137], and made up of many ſcales or plates, repleniſhed with a clear water, and pellucid veſſels very difficult to demonſtrate; inſenſible, and almoſt circular, yet broader at the noſe than towards the temples: it is termed the *cornea*, thro' which the light paſſes into the inmoſt part of the eye. This greedily imbibes water, and ſweats it out again. Before the anterior and flatter part of the ſclerotica, and alſo before the cornea, the conjunctiva is detached from each of the eye-lids, and cloſely conjoined to the ſclerotica by a proper cellular ſubſtance, that may be inflated (D.); which is repleniſhed with veſſels, partly red, and partly pellucid continuations of red ones.

DXII. The origination of the *choroides* is from the circumference of a white circle, terminating the ſubſtance of the optic nerve, in that part where the retina and the central artery are expanded from it, and perforate it by many ſmall foramina. From hence it ſpreads within the ſclerotica, concentrically adhering thereto by a cellular ſubſtance and many veſſels, which enter from the choroides into the ſclerotica. This membrane is

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[137] That limpid water exſudes through the moſt ſubtile pores, and contributes ſomewhat to increaſe the quantity of the tears.

is outwardly of a brown colour, but inwardly of a more ruſſet brown or almoſt black, both which colour and ſurface are ſeparable by maceration: the innermoſt may be diſtinguiſhed by the name of *Ruyſch;* but grows white through age. When this has extended itſelf as far as the beginning of the pellucid cornea, it there joins itſelf more accurately to the ſclerotica by a cellular ſubſtance; from whence going off almoſt circularly in a different courſe, it forms a kind of rim, called *orbiculus ciliaris:* namely, the coat, which was before ſpherically expanded, now ſubtends circularly from the arch of the cornea, a little convex outwardly, and with a deficiency in its middle; from whence a circular parallel portion is taken out, ſo as to form a foramen or hole, called the *pupil*, which is ſeated nearer toward the noſe, and is larger toward the temple. The anterior part of this round rim, is called the *iris;* and the back-part, ſeparable from the former by maceration, is, from the black colour with which it is painted, called *uvea.* On the anterior ſurface of the iris appear numerous ſtripes, extended like rays, of various colours in different people, the whole covered as it were with little locks of wool. Theſe go off beyond the pupil into a ſerrated circle, from which tend other ſimilar ſtreaks, even to the edge of the iris. They are ſerpentine in a broad pupil, but ſtraight in a narrow one. On the poſterior face of the uvea is much black pigment; which being waſhed off, ſtraight radiated ſtreaks appear, produced into the pupil, but not woolly. Orbicular fibres, concentrical with the pupil, I have not been able to obſerve, neither with the naked eye, nor with a microſcope, even in an ox; but only in the uvea, an internal circle diſtinguiſhed by obſcurer rays, but leſs woolly. In the human fœtus, the pupil and the iris being produced, makes a complete circle[138].
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[138] This is the famous membrana pupillaris, ſufficiently deſcribed by Albinus, Wachendorff, Hunter, Haller, Walker, and myſelf. In the ninth month of pregnancy it generally diſappears, rarely remaining after birth, though I once ſaw it. While it is preſent, the cameræ of the eye are really ſeparated.

That part of it which is drawn over the pupil is of a vaſcular texture. About the time of birth, it gradually retracts, diſappears, and allows a free paſſage to the rays of light.

DXIII. Though the iris has little ſenſation, and is not endowed with any mechanical irritability; yet in a living man, quadruped, or bird, it is conſtricted on every greater degree of light, and is dilated on every ſmaller one; hence it is rendered broader for viewing diſtant objects, and narrower for viewing ſuch as are near. The cauſe of this dilatation ſeems to be a remiſſion of the powers reſiſting the aqueous humour; an argument of which, is the dilatation of the pupil, occaſioned by debility, and which ſucceeds ſyncope and death. The contraction is more obſcure, and perhaps only depends on the ſtronger afflux of humours into the colourleſs veſſels of the iris, into which theſe veſſels are extended[139]; and, along with theſe, the iris is rendered longer, and ſhuts the greater part of the pupil: ſo that this motion has ſomething in common with a beginning inflammation. The pupil is more evidently moved and contracted; as the eye gradually grows callous in old people, it is rendered almoſt immoveable. In an animal twenty or thirty hours dead, I have ſeen the iris extend by heat, and ſhut the pupil.

DXIV. Behind the uvea, from the ſame circle by which the choroides and ſclerotica join together, and outwardly adhere to the cornea, ariſe thick ſtripes, extended from the choroides, elegantly wrinkled with parallel

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[139] And my own experiments alſo have convinced me, that the iris does not belong to the parts endowed with regular irritability; for the ſolar light, or that of any other lucid body, if it ought to exert its effects upon the iris, that part of it taken in through the narrow channel ought to be conveyed to the retina; whereas, directed upon any other place of the iris, it remains without any ſuch effect. Theſe phenomena of the motion of the iris alſo convince me ſo much the more; beſides anatomical proofs, by which it is undoubtedly certain, that it has no real muſcular fibres, and that the contraction and dilatation of the pupil is rather to be aſcribed to the veſſels than to muſcles, although Janin endeavours to prove the preſence of muſcles by chirurgical reaſoning.

rallel veſſels, ſpread under them, which are conjoined by feather-like looſe and thin foot-ſtalks, into the retina, every way ſpread with a good deal of black paint; and departing, after the manner of a perforated ring, inward from the tunica choroidea, they ſpread upon the vitreous humour; and, laſtly, are laid on the capſule of the cryſtalline lens, but do not adhere to it, and are called by the name of the *ciliary ligaments*. The origin of the black pigment we are as yet unacquainted with; nor can any glandules be found, which ſome have aſſigned for its ſeparation. Among its other uſes, one ſeems to be to keep firm the cryſtalline lens. In infants, this ſame mucus has the image of a radiated flower behind the ciliary proceſs.

DXV. But the *retina*, which is truly a continuation of the medulla from the optic nerve, is next expanded into a ſphere concentric with the choroides, extremely tender, and almoſt of a mucous conſiſtence, diſſolvable by a blaſt; and this immediately embraces the vitreous body. But when the retina has extended itſelf as far as the ciliary proceſſes, it follows their courſe, making their ſtripes and ſmall arteries its foundation or ſupport in its courſe to the cryſtalline lens, to the capſule of which it adheres; and if we may believe the obſervations of ſome anatomiſts, as well as our own, ſpreads upon its ſurface [140].

DXVI. Theſe coats of the eye, which inveſt and ſupport each other, after the manner of an onion or other bulbous root, give a ſpherical figure to the eye, and include its *humours*: by which name are underſtood commonly three ſubſtances; the one a ſolid, the other a ſoft body, and the third truly a liquor. Firſt, then, the common ſurface of the retina is, on all ſides, filled by the principal or *vitreous* humour, which is contained in a thin pellucid membrane of its own, of a cellular fabric, in the intervals of which is confined a moſt clear liquor, a little denſer than water, which entirely evaporates by heat, like the aqueous humour: from which nature it does not eaſily degenerate, even in old people. Its veſſels, which are moſt manifeſt in fiſh, lie in the back part; are moſt beautifully radiated from the central trunk of the retina, embracing the convexity of the vitreous humour; and are inſerted into a circle formed by other arteries coming from the choroides, not far from the lens, and which I have ſeen in a ſheep. The vitreous membrane, which is tender conſidering its body, is yet grown to the lens in two places, before and behind; ſo that the middle hollow ring is intercepted between both inſertions, round the cryſtalline lens. Afterwards it is divided by ſome little ropes. The ſtreaks of the ciliary body imprint their marks on the anterior face of it.

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[140] Among all my obſervations upon the eye of man or of brutes, I find none to favour the opinion that the retina is ſpread over the capſule of the lens. I have ſeen the end of that medullary membrane every where circumſcribed behind the greateſt circle of the lens.

DXVII. But, in the fore-part of the vitreous body, behind the uvea, there is an orbicular depreſſion or ſinus conſiderably deep, into the cavity of which the *cryſtalline lens* is received, though that be leſs properly ranked in the claſs of humours. The figure of this lens is made of two elliptical convex portions or ſides, the foremoſt of which is flatter, and the poſterior more gibbous. The ſtructure of it is that of concentric plates or ſcales, ſucceeding each other, and compoſed by the fibres themſelves, elegantly figured and contorted, and connected by cellular fibres, ſo as to form a tender cellular texture. Betwixt the cryſtalline leaves is alſo contained a pellucid liquor, which in old age turns of its own accord to a yellow colour. The innermoſt ſcales lie cloſer together; and form at laſt a ſort of continued nucleus, harder than the reſt of the lens: it does not ſo adhere to the capſule, but, when that is broke, it very readily leaps out; and ſome ſay that a little water is effuſed around it. Its artery is from the retina, which perforates the middle of the vitreous humour; that is, the poſterior one; for the veſſels in the fore-part are not yet known. This whole lens is contained in a ſtrong, thick, elaſtic capſule of a pellucid membrane, more firm in the fore-part, which is lined backward by the vitreous tunic.

DXVIII. Laſtly, the *aqueous humour*, which is extremely clear and fluid, and renewed again if it be let out[141], is ſeated in a ſmall ſpace of a curve-lined triangular figure betwixt the uvea and cryſtalline lens, and in a larger chamber that is before betwixt the iris and the cornea. This humour ſeems to exhale from the ſmall arteries of the iris, uvea, and ciliary proceſſes; being again abſorbed into ſmall veins of the ſame parts, while ſome portion of it is drunk up and exhaled thro' the cornea. This humour alſo waters the uvea and capſule of the lens. About the beginning of the preſent century, the ſpaces filled with this liquor were called the *cameræ* of the eye; the fore one between the cornea and iris; the poſterior one, which is ſmall, between the circumference of the cryſtalline lens and the uvea.

DXIX. The eye, thus framed, is outwardly ſurrounded with muſcles for its government and direction. Namely, into the circle of the ſclerotica, which is next to the cornea, are inſerted four ſtraight muſcles, ariſing from the dura mater of the optic nerve at the bottom of the orbit; where, departing from the nerve, they cohere with the perioſteum, forming, as it were, one circle; from whence, going forward, their bellies lie round the bulb of the eye, and terminate again by their aponeuroſes, meeting together in another circle into the ſclerotica. Of theſe, the elevator is the leaſt, and the abductor the longeſt. The office of theſe muſcles appears very plainly in each of them apart; ſince, being bent round the convex bulb of the eye, as about a pulley, they muſt, of courſe, elevate, depreſs, or turn the globe of the eye either to the noſe or to the temple. Moreover, two of them acting together may turn the eye in a diagonal betwixt the former directions; as upwards and outwards, upwards and inwards, &c. Laſtly, when all the four ſtraight muſcles are contracted, there is no doubt but they draw the whole eye towards its origin within the orbit, by which means the cryſtalline lens is moved nearer to the retina.

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[141] It is undoubtedly included in a very tender membrane, which cannot be made viſible and preſerved without the moſt concentrated lixivial fluid.

DXX. But the two *oblique muſcles* of the eye are of a more compound fabric. The upper of theſe, ariſing together with the recti, is long and ſlender, aſcending forward to a notch in the os frontis, which is completed by a double ligament, cartilaginous on each ſide, and hollow in the middle, almoſt quadrangular, for ſuſtaining the tendon of the muſcle. Through this canal paſſes the tendon of the obliquus ſuperior; which being again reflected backward and downward, included in a capſule of its own, is inſerted into the globe of the eye behind the ſtraight muſcles. This draws the globe forward and upward, in a manner out of the orbit, that the eye may take in a larger field of viſion; it alſo turns the pupil inward and downward. The other *leſſer oblique* muſcle, ariſing from a ſinus of the lachrymal foramen in the upper jaw, aſcends immediately outwards from the os unguis round the globe of the eye, and is inſerted by its tendon into the ſclerotica behind the external rectus: whence it appears, on its part, to turn the eye downward and outward; and of courſe, contrary to the former, to direct the pupil upward and inward.

DXXI. But there are other more minute muſcular motions performed in the eye, which preſuppoſe a knowledge of the nerves belonging to this organ [142]. And, firſt, we have already ſpoken of the optic nerve (DIX, DX). The fourth pair goes only to the larger oblique muſcle, and the ſixth pair belongs to the ex-

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[142] It is an ancient obſervation, that the eye, with its muſcles, in proportion to their ſize, is ſupplied with an incredible number of nerves, making uſe of the whole ſecond, third, fourth, and ſixth pairs, except a root to the intercoſtal, and a great part of the firſt branch of the fifth. Janin has told us, that the eye has nerves from the pathetic and ophthalmic alone.

ternal rectus. The third and fifth pair produce the principal nerves in the eye; and of theſe, the firſt branch of the fifth produces the opthalmic nerve, and ſends off a ſmall nerve from its entrance into the orbit, to the eye-lid and lachrymal glandule; it then conjoins with the ſecond branch of the fifth pair, and with the temporal branch of the third and fifth pair. After having entered into the orbit, its trunk divides into two. The upper and larger ſubdivides into two, which are ſpent upon the forehead and eye-lids: but the lower, going inwards above the optic nerve, ſends out long ſlender filaments to the outer part of that nerve, which, joining with another filament of the third pair, makes up the ophthalmic ganglion, and ſends off one or two ciliary nerves. Finally, having given off a nerve, running to that of the noſe (CCCCLVII.), it is then ſpent upon the different parts of the internal angle of the eye.

DXXII. But the principal dignity of the *third pair* lies in giving off a branch upwards to the ſtraight muſcles of the eye, and to the eye-lids; and then, going forward with its trunk under the optic nerve, it ſends out three branches together to the lower and leſs oblique, and to the internal muſcle; after this, or often before, (from its trunk, and ſometimes from a branch of the lower obliquus), aſcends out another ſhort and much thicker nerve, which ſometimes joins the root of the fifth (DXXI.), or is ſometimes ſolitary; which, under the abductor muſcle, conſtantly forms the oval ophthalmic ganglion. From that ganglion, and ſometimes from the trunk of the third or fifth, go out four or five ciliary nerves in a crooked courſe, playing round the optic nerve in their courſe to the globe of the eye, where they enter the ſclerotica almoſt in its middle, in company with its longer ſmall arteries or veins; and running thence ſtraight forward through the choroides, they paſs viſibly to the iris, and ſeemingly to the ciliary proceſſes. Other very ſmall nerves, originating from the ſame ganglion, remain in the tunica ſclerotica.

DXXIII. Another more obſcure and leſs eaſily demonſtrable

monſtrable motion in the eye, is that of the ciliary proceſſes (DXIV.); which, lying incumbent upon the furrows of the vitreous membrane, ſeem, by their action, to preſs back that body, ſo as to bring the lens forward, and ſeparate or remove it farther from the retina. But I have never ſeen, in all the animals I have diſſected, any thing like a muſcle in this ciliary body; but a membrane which ſupports the ſmall veſſels. As for any ſphincter of the pupil, or a conſtrictor of the cornea, mentioned by ſome writers of note, or even moving fibres, which others have imagined proper to the cryſtalline lens, they are in nowiſe ſupported by anatomy, nor are they conſiſtent with the perpetual hardneſs of texture obſervable in the lens and cornea of moſt animals.

DXXIV. Moreover, to the hiſtory of the eye belongs a deſcription of the veſſels, which in this part have a beautiful fabric. But all of thoſe which belong properly to the ſeveral parts of the eye itſelf come from the ophthalmic artery, a branch of the internal carotid (CCCXVI.). This, creeping along under the optic nerve, ſends out, as principal branches, the upper and lower ciliaries, one or more; the lachrymalis, from whence the poſterior running to the noſe, and internal part of that belonging to the arch of the tarſus; afterwards the muſcularis inferior, the anterior recurrent to the noſe, the uppermoſt muſcularis, and the palpebralis; from whence, with the former branch, ſprings the arch of the tarſus. Laſtly, it goes out forward to the face and adjacent parts of the noſe. But the opthalmic branches, belonging to the inner fabric of the eye, are the poſterior and middle ciliaries; which, ariſing from the trunks before mentioned, and playing round the optic nerve, in four or more branches, in a ſerpentine courſe, go partly in with the optic nerve at its firſt entrance, and are partly extended further to near the middle of the ſclerotica[143], where they ſend in forty or more little arteries to the choroides, which make firſt beautiful ramifications upon the external ſurface of that membrane, round, and like the branches of trees; from whence they proceed inwardly in a more direct courſe, and at laſt go to the *circle* of the uvea.

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[143] Neither in man in general, nor even in the larger brutes, do the

DXXV. But ſeveral of the ſmall arteries of the tunica choroides gradually decline towards the interior parts of the eye; and, being covered with a kind of cellular woolly matter, go to the ciliary proceſſes, through each of which run out two ſmall arteries, ſcattering vaſcular woolly-like locks, united by an handle at their apex.

DXXVI. Other ſmall arteries alſo, likewiſe ariſing from the ciliary ones, but few in number, moſt commonly two, come to the ſame baſis from which the membrane of the uvea originates. There, ſpreading in various directions, they ſurround the root of the uvea with their branches, and are joined into a circle, into which the anterior ciliares mix themſelves; which are ſmall arteries ariſing from the muſcular branches of the ophthalmic, near the origin of the pellucid cornea; perforate the ſclerotica by twelve or more branches, and together make up the circle of the pupil. From that circle, and likewiſe from the fore-mentioned anterior ciliary arteries, independent of the middle circle, are diſtributed veſſels, both on the anterior face, which makes the iris, and on the poſterior face of the uvea, together with the ciliary proceſſes; the veſſels are diſtributed, both ſtraight and ramified; the iris is full of a liquor of a bluiſh colour, otherwiſe brown; and the uvea is ſpread with a good deal of a black paint, without which it is naturally white. In the uvea, at ſome diſtance from the pupil, they frequently form an imperfect circle.

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the ciliary arteries ſimply perforate the ſclerotica; but any whole trunk of the ciliary artery enters the foramen on the outer ſide of the ſclerotica, and in the very ſubſtance of the ſclerotica it ends between the plates of this tunic in a plexus of thin threads, from which five or ſix leſs branches iſſue; and coming through as many holes out of the inner ſurface of the ſclerotica are diſtributed through the choroid.

DXXVII. But from the ſame opthalmic and its trunk, or from the lachrymal branch, or from one of the ciliaries, one or more branches enter into the optic nerve; the principal central artery of the retina penetrates thro' the medulla of the nerve, and, going out of the apex of the papilla (DX.), divides in the centre of the retina; from thence ſpreading every way in company with the retina itſelf[144], by ſo many branches, when traced by a ſkilful anatomiſt, that that vaſcular net-work is taken for a proper membrane. Sometimes a leſſer branch goes along the centre of the nerve to the retina, and is in like manner ramified through it. It is certain, that from theſe branches the minute pellucid ones of the vitreous tunic are produced, as well as the poſterior artery the lens. The centre of theſe arteries, entering the retina, is the celebrated *porus opticus* of the ancients.

DXXVIII. The veins of the eye, in general, ariſe from the ophthalmic vein, which here comes from the vein of the face; and, going out of the bony orbit, is inſerted into the cavernous ſinus[145]. The internal veins of

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[144] Theſe do not agree with the late obſervations made by Mr Walter and myſelf. I have carefully followed the central artery in its courſe after diſſecting the optic: it paſſes, without giving any branch to the retina, through the vitreous humour, and there very tender threads go off; but the whole trunk of the central artery ends very prettily upon the poſterior ſurface of the capſule of the lens, as was painted in my publication in the New Gottenburgh Commentaries.

[145] Since the veins of the eye had been neither well deſcribed nor elegantly painted, I was led to make new drawings of them along with the new work of the immortal Zin. But that great and indefatigable anatomiſt Walter anticipated the honour, and has rendered almoſt ſuperfluous any of my drawings, one or two excepted, which have now come out.

In two places, and by two ways, the venous blood of the eye is returned, partly into the ſinus cavernoſus, in which is inſerted the poſterior part of the vena magna ophthalmica; which Walter calls *ophthalmica cerebralis*, and I the *ſuperior magnus*. It collects all the blood from the glandula lachrymalis, ethmoidal veins, the ciliary and muſcular ones coming from the ſuperior part of the eye. It is partly poured into the great facial vein; into which the anterior part of the eye are fewer in the middle of the ſclerotica, which they perforate with larger trunks, and form buſhes or trees of a roundiſh figure, which commonly keep the middle of the baſis of the tunica choroides; ſome of them, which are long, reach even to the origin of the uvea: others, in the fore part, are ſimilar to arteries: another central vein, like an artery, goes to the retina of the optic nerve. The pellucid or watery veſſels differ not in their courſe from thoſe which convey blood. There are alſo lymphatic veſſels ſaid to have been ſeen by ſome in the retina; but the obſervation has not been often enough repeated for us to depend on it.

DXXIX. So far with reſpect to the anatomy of the eye; but that the action of this organ lies wholly in the reception of light, excepting only a few doubts, appears very plainly from phyſical and mechanical experiments. Light then is a matter either the ſame with, or very nearly approaching to, that of fire[146], extremely fluid and ſubtile, penetrating through all even the hardeſt bodies, without receiving alteration from any length or diſtance in its courſe; moving with ſuch a very great velocity, as to run through the diſtance between the ſun and earth in the ſpace of about eight minutes and thirteen ſeconds. The light we have in our atmoſphere proceeds either from that of the ſun, whoſe body ſeems to have the power of impelling to us, in right lines, the matter of light, which is confuſedly ſpread

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of the great ophthalmic vein carries the blood from the anterior part of the eye, the tunica conjunctiva, and palpebræ. Another ophthalmic vein has been added to theſe, called by Walter *ophthalmica facialis*, and by me *ophthalmica inferior minor*; which tranſmits the blood of the inferior parts of the eye, the ciliary and muſcular veins, partly into the major ophthalmica, and partly through a deep branch into the vena facialis.

[146] If we compare the late experiments of Mayer, Weigel, Bikker, and Herbert, with thoſe of Sachs and Boerhaave, we may aſſert with the greateſt probability, that there is a peculiar matter in nature, which is fitted for producing heat and ſpreading light, according to the different motion and direction of its particles.

ſpread around; or elſe it proceeds from ſome other ignited point or lucid body; from whence the rays ſpread every way, as from a centre to all points of a large ſphere, ſo as to fall upon the ſurfaces of bodies; from whence again it is reflected into the eye, from the enlightened ſurfaces, in angles equal to that of their incidence, ſo as to render the bodies from whence it thus flows to the eye both viſible and of ſome colour.

DXXX. It is now ſufficiently evidenced from experiments, that light is compoſed of rays in right lines, almoſt without any phyſical breadth or thickneſs; and yet, that each of theſe rays is again ſeparable into ſeven other permament and immutable rays of a leſſer kind. The known properties of theſe rays are, that all of them, conjoined together, conſtitute a white beam; which, being refracted by the minute ſurfaces of bodies, are ſubdivided into rays of a red colour, which are more conſtant or permanent, hard, and leſs refrangible; next to which follow thoſe of an orange, of a yellow, green, blue, and indigo or violet colour; of which thoſe are always weaker and more refrangible, which are farther diſtant in order from the red rays[147]. A ſhadow ariſes from a deficiency in the reflected rays. Thoſe primitive rays, variouſly compounded together with ſhade, make up all the variety of colours.

DXXXI. The colours, then, which ſeem proper to bodies, ariſe hence; that the minute ſurfaces of their conſtituent ſolid particles, by which their pores or vacuities are limited, do, according to the difference of their thickneſs, denſity, &c. reflect or ſeparate the rays of light, ſo as to ſend more of one kind or colour to the eye than another; whilſt moſt part of the remaining rays are loſt by repeated reflections within the pores of the ſubſtance: ſo that the ſtrongeſt and thickeſt particles reflect a white colour; thoſe next in denſity and ſize, a red colour; till at laſt the minuteſt ſurfaces reflect a violet colour. Thoſe bodies are opake, which retain the rays within their ſubſtance, without permitting any to paſs through them: which ſeems to follow from the largeneſs and the number of the pores, to the ſides of which the light is attracted; which pores are filled with ſome matter that has a power of refraction, different from that which the light ſuffers from the parts of the body itſelf. Theſe principles we embrace, till a new theory that places the diverſity of colours in vibrations of different celerities ſhall be better eſtabliſhed; neither is it our buſineſs to concern ourſelves with this matter.

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[147] To the hypotheſes concerning the variety and riſe of colours, according to Newton, Mariot, and Euler, the late Mayer has added a new and very probable opinion, that there are only three primary colours, yellow, blue, red; traces of which conjecture are now found in Lomonoſs, but more extended by Lambert and Erxleb, by means of the elegant pyramids of colours ſo called.

DXXXII. Theſe rays, falling obliquely upon the ſurface of liquors of various denſities, paſs through them with a change in their direction, by variouſly receding from or approaching nearer to a perpendicular: and this is called their *refraction*. In general, the denſer the medium, the more are the rays bent towards the perpendicular; excepting only inflammable liquors, which, by a peculiar property, draw the rays more to a perpendicular than in proportion to the denſity of the liquor. The proportions of the angles of incidence to thoſe of refraction are obſerved to be conſtant enough; ſo that the ſine of the radius of refraction from air into water is to the ſine of the angle of incidence as 3 to 4: and in the radius, paſſing from air into glaſs, the ſine of the incidence is to that of refraction as 17 to 11; and from water into glaſs, as 51 to 44 [148].

DXXXIII. Rays, which come through the air with but little divergency, (as thoſe of the ſun do on account of their immenſe diſtance, or as in general do any rays that come from the diſtance of above 100 feet), falling out of the air upon denſer bodies, ſpherically convex, are reflected to greater angles, as of 48½ degrees; nor are they under that meaſure. If the angles are ſmaller, and they penetrate the refracting medium, they are there ſo refracted, as to meet together in one point, which is called their *focus*. This point always falls within the axis or radius that is perpendicular to the ſurface; whence it becomes permanent and unchangeable. So that the focus of rays, paſſing from air into a ſphere of water, will be diſtant from the axis one ſemidiameter of the ſphere; and in a globular glaſs, it will be diſtant a fourth part of the diameter: but in a convex lens of glaſs, that is, part of a ſphere not leſs than thirty degrees, and equally convex, the focus will be likewiſe diſtant one ſemidiameter; yet ſo that the rays will meet, not in a ſingle point, but in a little circle.

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[148] We cannot read the works of Smith, Kaeſtner, Prieſtley, and Klugel, without admiration, where they have explained the uſe of optics, in letting us underſtand the theory of animal viſion.

DXXXIV. Therefore the rays of light, whether direct or inflected, fall in ſuch a manner upon the tunica cornea of the eye, as to form a moſt ſharp cone betwixt the lucid point and the membrane upon which they are ſpread: the baſis of which cone will be the ſurface of the cornea, and the apex in the radiant point; yet ſo that all rays in this cone may, without any ſenſible error, be reckoned parallel with each other. Among theſe, there are ſome rays reflected back from the cornea, without ever penetrating the ſurface; namely, all ſuch as fall upon that membrane in a greater angle than that of forty degrees. Others, which enter the cornea at very large angles, but leſs than the former, and fall in betwixt the uvea and ſides of the cryſtalline lens, are ſuffocated or loſt in the black paint that lines the uvea (DXII.) and the ciliary proceſſes (DXIV.); but thoſe rays only fall upon the ſurface of the lens, which enter the cornea at ſmall angles, not much diſtant from the perpendicular, or at moſt not exceeding twenty-eight degrees. By this means, all thoſe rays are excluded which the refracting power of the humours in the eye could not be able to concentrate or bring together upon the retina; without which they would paint the object too large and confuſedly.

DXXXV. Thoſe ſlender rays, therefore, coming thus to the thick cornea, which is denſer than water, and forms the ſegment of a ſphere, ſuffer thus a greater power of refraction, and paſs through it in a more conſiderable degree towards the perpendicular; namely, about a fourth part: but theſe rays falling with but little convergency upon the aqueous humour, which is ſmall in quantity and almoſt like water, making there no focus, becauſe of the nearneſs of the humour to the cornea, go on nearly parallel, or little converging, to the next adjacent ſurface of the very pellucid or cryſtalline lens; becauſe their divergency was conſiderably corrected by the refracting power of the cornea. Moreover, the cornea being convex, and part of a leſs ſphere than that of the ſclerotica, receives and collects a greater number of rays than if it was flatter with a leſs ſurface.

DXXXVI. The refracting power of the cryſtalline lens, which exceeds that of water, may be underſtood from its greater hadneſs and weight; although we have no certain meaſure. In this lens, therefore, and more eſpecially in is poſterior very convex ſide, the rays will converge greatly, and paſs thence into the vitreous body.

DXXXVIII. This vitreous body is denſer than water in which it ſinks to the bottom; but rarer than the cryſtalline lens; and continues to bend the rays a little more gently towards the perpendicular, till at length the rays coming from the point of diſtinct viſion, are concentrated into a very ſmall part of the retina, where they paint an image of that object from whence they come; but in a poſition inverted, from the neceſſary decuſſation or croſſing of the rays. The manner in which the images of objects are thus painted, may be ſeen experimentally in an artificial eye, or by a natural eye when the back part of the ſclerotica is cut off, and a piece of paper placed to receive the object. But the image we ſee is painted on the outer ſide from the optic nerve within the bounds of the viſual axis; yet ſo that it is not a mere point, but has ſome degrees of breadth; ſince we ſee many objects at once, whoſe images muſt be in diſtinct points of the painted field. And there an object is ſeen moſt diſtinctly, becauſe the rays arrive thither nearly perpendicular. But frequently this point of viſion does not fall on the ſame place on both of the eyes. When the lens has been couched or diſplaced, the vitreous body, with a weaker refracting power, uſually ſuffices to bring the viſual rays together to a focus.

DXXXIX. Is it altogether falſe that the object is painted on the retina? Or is this picture made on the choroides? Is this new opinion confirmed by an experiment, by which it is found that the place where the optic nerve enters is blind? and which is thus explained, that there is in that place no choroides but the bare retina, and that thence there is no viſion. But this is repugnant to a very well known obſervation, namely, that the retina is a moſt ſenſible nervous medulla; and that the choroides conſiſts almoſt entirely of a few ſmall nerves, and of veſſels moſt certainly blind. This is likewiſe contradicted by the very great variety of the choroides in animals; the equally great conſtancy of the retina; and the black ſpots, which, even in man, obſcure the exterior ſurface of the retina. But by this experiment we know the reaſon why the optic nerve is not inſerted into the axis of the eye, but into its ſide. For thus, except only in one ſingle caſe, where there is an impediment in the concourſe of lines drawn through the centre of the optic nerves, the one eye ſees and aſſiſts that whoſe blind ſide is turned towards the object.

DXL. But ſince the neceſſary offices of human life require a diſtinct object to be painted upon the retina, not only by the rays which come from one certain diſtance, but likewiſe by rays which come from very different parts more or leſs diſtant; therefore, it is to be believed, that the neceſſary change is produced in the eye by its own proper cauſes. Other famous anatomiſts have ſuppoſed the lens moveable by the powers before mentioned (DXIX. DXXIII.) This art of ſeeing diſtinctly is ſaid to be learned by experience, it being unknown to an eye lately couched of a cataract. Alſo, in an artificial eye, the uſe and neceſſity of this motion, it is ſaid, may be plainly perceived. Therefore too great a divergency of the rays, as in thoſe which come from objects very cloſe to the eye, is corrected by a removal of the lens farther from the retina, ſo as to bring the focus of the diverging rays upon the retina itſelf, which would otherwiſe have fallen behind the eye; for the refracting power of the eye being determined, that which will unite the focus of rays coming from the diſtance of three feet, ſo as to make them fall perfectly upon the retina, will not be able to collect together into the ſame point thoſe rays which come from the diſtance of three inches; and rays ſtill more diverging will meet together yet farther behind the eye, if they are not collected together by a greater refracting power.

DXLI. But thoſe rays, which come from parts very remote, and which may be therefore counted parallel, will meet together before the retina, in the vitreous body; and again ſeparate according to the nature of rays from the point of concourſe, as if it was a lucid point: to remedy which, therefore, it is probable that thoſe powers (DXXIII.) remove the cryſtalline lens back from the cornea nearer to the retina; that the rays, which come together from a certain diſtance to the lens, may be alſo united together at a certain proportionable diſtance on the retina. For an eye, that will collect the rays coming from ſeven inches, ſo as to unite them on the retina, will collect thoſe together before the retina which come from a diſtance of three feet. It was therefore perfectly neceſſary for the eye to be made thus changeable, that we might be able to ſee diſtinctly at various diſtances. But the point of diſtinct viſion is in that part of the retina where the given object is painted in the leaſt compaſs poſſible. The powers cauſing the viſual rays to unite or converge on the retina, are often very different in the two eyes of one and the ſame perſon, ſo as to render one eye nearly preſbyoptical or long-ſighted, and the other myoptical or ſhort-ſighted.

DXLII. Theſe and other things ſimilar are commonly received and taught more eſpecially by the mathematicians, who more readily perceive the neceſſity of theſe changes. But yet there is no power in the human eye which can either move the cryſtalline humour out of its place, or compreſs it. But we do not perceive this faculty in ourſelves: for we move a book nearer to our eyes when it is too far off, ſo as to appear confuſed; which we would have no occaſion to do, if by changing the internal figure of the eye we could correct the fault of the diſtance: and through a ſmall hole, we perceive an object only ſingle in the point of diſtinct viſion, but double in every other. Perhaps the contraction of the pupil may do ſomething, by which we can perceive more diſtinctly ſuch objects as are near.

DXLIII. But this artifice of the eye is not ſufficient in all perſons. For there are now a greater number of people than formerly employed in a ſtudious or ſedentary life, and taken up with the obſervation of more minute objects; by which the cornea is rendered more convex and denſe, and the cryſtalline lens more ſolid and of leſs ſegments; while the eye itſelf, by the weight of the humours, is more elongated, and the reſt of the humours themſelves are probably more denſified: many or all of which circumſtances attend the eyes of one perſon. In ſuch, the iris is ſenſible in a ſmall light; whence, by winking, or ſtraining the eyelid, they are denominated *myopes*, ſhort or near ſighted. In theſe, the point of diſtinct viſion is very near to the eye, from one to ſeven inches from before the cornea; but they ſee remoter objects more obſcurely, without being able to diſtinguiſh their parts. The reaſon of this is evident; ſince, from the forementioned cauſes, there is a greater refracting power of the humours, by which the diſtant and conſequently parallel rays are obliged to meet in their focus before the retina; from whence ſpreading again, they fall upon the retina in many points. Thus alſo to a good eye, the ſenſe of objects which are too near the cornea is confuſed; becauſe the rays coming from thence are ſpread all over the retina, without being collected towards the centre.

DXLIV. The remedy for this fault in the ſight is to correct it in its beginning, by viewing diſtant places, by keeping the eyes from minute or near objects, and by the uſe of concave glaſſes; or by viewing things through a ſmall hole, by which the light is weakened. When the diſorder is confirmed, the remedy is a concave lens, which takes off a degree of the refracting power in the humours, cornea, and cryſtalline lens, in proportion as it is more concave; by which means the focus of rays from remote objects is removed farther behind the cornea, ſo as to fall upon the retina. This glaſs ought to be a portion of a ſphere, whoſe diameter is equal to the diſtance of diſtinct viſion from the naked eye, ſquared by the diſtance of diſtinct viſion in the armed eye, and divided by the difference betwixt them. Age itſelf advancing, gives ſome relief to the ſhort-ſighted; for children are in a manner naturally myoptical: but, as the eye grows older, it becomes flatter, in proportion as the ſolids grows ſtronger; and, contracting to a ſhorter axis, the converging powers of the lens and cornea are diminiſhed.

DXLV. Another diſorder of the ſight, contrary to the former, troubles people who are often looking upon very diſtant objects, and is more eſpecially familiar and incurable in old people. In ſuch, the cornea and cryſtalline lens are flatter, and the humours of the eye have a leſs refracting power. Hence near objects, whoſe rays fall very diverging upon the cornea, appear confuſed; becauſe the converging or refracting powers of the eye are not ſufficient to bring the rays together in a focus upon the retina, but the rays go on ſcattered through the retina, and through the point of their pencil behind the eye; from whence viſion is confuſed. The point of diſtinct viſion among preſbyopi, or old or long-ſighted people, is from the diſtance of fifteen inches to three feet.

DXLVI. Such perſons are, in ſome meaſure, relieved by looking through a black tube held before the eye; by the uſe of which the retina grows tenderer, and the rays come to the eye in a parallel direction. The remedy here is a convex lens of glaſs, which may cauſe the rays to converge and unite together ſooner in a focus, that it may not fall behind the eye, but upon the retina. The diameter of the ſphere, of which ſuch a lens ought to be a portion, is determined as before (DXLIV,) There is no hope from age, which increaſes the malady.

DXLVII. The medium betwixt ſhort and long ſighted is the beſt, by which a perſon can ſee diſtinctly enough objects that are both near and remote; and of this kind we reckon an eye that is able to read diſtinctly at the diſtance of one foot. But to this are to be added other neceſſary conditions; ſuch as a perfect clearneſs of the humours; a due mobility of the eye itſelf, and its parts; a ſenſibility of the pupil and retina, neither too tender nor too tough.

DXLVIII. But the mind not only receives a repreſentation of the image of the object by the eye, impreſſed on the retina, and transferred to the common ſenſory or ſeat of the ſoul; but ſhe learns or adds many things from mere experience, which the eye itſelf does not really ſee, and other things the mind conſiders or interprets to be different from what they appear to her by the eye. And, firſt, the *magnitude* of an object is judged of by an optical angle intercepted; as the baſis of a triangle betwixt the cornea, and as the point of a cone betwixt the radiant object. From hence, things very near ſeem large, and remote objects ſeem ſmall. Hither may be referred the power of microſcopes, by which objects are made to appear to us ſo much larger, as the diſtance of the focus of the lens or magnifier is leſs than the diſtance of diſtinct viſion; when, in reality, they do not appear larger, only more diſtinct and lucid; whence the mind judges them to be nearer,

DXLIX. The ſtrength of viſual light likewiſe is proportionable to the ſame angle, in the external day-light; and the multitude or number of the rays, joined with the ſmallneſs of the ſeat which they affect in the retina, occaſions near objects to appear brighter, and diſtant objects more obſcure; or if remote objects appear bright by their own light, the mind repreſents them as large, near at hand, or both.

DL. The *place* of a diſtant object appearing to one eye, is reckoned to be in a line comprehended by two other ſtraight lines drawn to the extremities of the body. If the ſame body is looked upon with both eyes, it will then ſeem to be in the concourſe of two lines drawn through the axis of both eyes to that object.

DLI. *Diſtance* we cannot perceive; and if a blind man, who never ſaw, ſhould by any means be reſtored to ſight, he would imagine every thing he ſaw to touch his eyes. Even we who are accuſtomed to judge by ſight, make many fallacious conjectures concerning the diſtance of objects: but concerning this we judge as well from the known diminution of the bulk of the body, as from the leſſer ſtrength of the light, and faint image of the object whoſe parts we are leſs capable of diſtinguiſhing, and from the number of bodies interpoſed, whoſe diſtance is known.

DLII. The *convexity* or *protuberance* of a body is not ſeen; but is afterwards judged of by experience, after we have learned, that a body, which is convex to the feeling, cauſes light and ſhadow to be diſpoſed in a certain manner. Hence it is, that microſcopes frequently pervert the judgment, by tranſpoſing or changing the ſhadows. The ſame alſo happens in that phenomenon which is not yet ſufficiently underſtood, by which the concave parts of a ſeal are made to ſeem convex, and the contrary.

DLIII. The viſible *ſituation* of the parts of an object, are judged by the mind to be the ſame with that which they naturally have in the object, and not the inverted poſition in which they are painted upon the retina. But it is certainly a faculty innate or born with the eye, to repreſent objects upright to the mind, whenever they are painted inverted upon the retina: for new-born animals always ſee things upright. And men who have been born with cataracts, without ever being able to ſee, are obſerved, upon couching the cataracts, to ſee every thing in its natural ſituation, without the uſe of any feeling, or previous experiences.

DLIV. One thing which impoſes upon the mind, is the continuance which external ſenſations make, during almoſt the ſpace of a ſecond of a minute, after they have been conveyed to the ſenſorium by the eyes; whence they are repreſented to the mind as objects really preſent. From hence proceeds the idea of a fiery circle from the circumrotation of a lucid body; and from hence proceeds the continuance of the ſhining image of the ſun, and ſometimes of other bodies, after they have been viewed by the eye.

DLV. Do we perceive only that object diſtinctly which is directly before that part of the retina which ſees moſt diſtinctly? And does the eye perſuade itſelf, that it ſees many objects at a time, partly from the duration of the ideas, and partly from the quickneſs of the motions of the eye? Concerning the moſt diſtinct viſion, this is moſt certain; but we cannot affirm it of that which is leſs diſtinct. Why do we ſee only one object with two eyes? Becauſe the ſenſation becomes one, and without difference, when we have ſimilar impreſſions of two objects. For, even without the concourſe of optic nerves, inſects who have numerous eyes perceive objects ſingle. Hence the images of two objects excite only one ſenſation, when they fall upon the ſame point of the retina; but two ſenſations ariſe from one object, when the images fall upon different parts of the retina. Whence proceed diurnal and nocturnal blindneſs? The former is common to many nations living in the warmeſt climates, under the brighteſt rays of the ſun, and to old men. The other happens in inflamed eyes, and young men of a hot temperament, and hence endowed with eyes vaſtly ſenſible. Whence do animals ſee in the dark? From a large dilatable pupil, and tender retina; a ſhining choroides, and one which reflects the light very ſtrongly. Why are we blind when brought out of a ſtrong light into a weak one? Becauſe the optic nerve, having ſuffered the action of ſtronger cauſes, is incapable of being moved by weaker ones. Whence have we a pain, by paſſing ſuddenly from a dark place into the light? Becauſe the pupil, being widely dilated in the dark, ſuddenly admits too great a quantity of light before it can contract; whence the tender retina, which is eaſily affected by a ſmall light, feels, for a time, an impreſſion too ſharp and ſtrong. Whether ſee we with one eye, or with both? Moſt frequently with one, and more eſpecially the right eye: but when both are employed together, we ſee more objects, and more plainly; and we alſo diſtinguiſh more points of the ſame object, and judge better of their diſtances.

CHAP. XVIII.

Of the INTERNAL SENSES.

DLVI. THE organs of the ſenſes have hitherto been conſidered and diſcuſſed ſeparately. We now ſee, that it is common to them all, that the tender pulp of the nerve, being ſtruck or impreſſed by external objects, conveys, by the nervous ſpirits, ſome change to that part of the brain where the impreſſed fibres of the nerve firſt ariſe from the arteries (CCCLXXII.) We know nothing more, than that new thoughts are thus excited in the mind, whenever ſuch a change, produced upon any organ of ſenſe, is conveyed to the firſt origin of the nerve which receives the impreſſion. For thought is not the expreſs image of the object, by which the ſentient nerve is affected. What in common has the idea of redneſs with a ſlightly refrangible ray, ſeparated from the ſeven portions of the whole ray? Nor is it conſiſtent with optical principles, that an object, painted by rays upon a ſoft white nerve, can be, in a long tract of perfect darkneſs, conveyed through a very opaque body to the origin of the optic thalami. There is nothing in the pain of burning that can repreſent to the mind a ſwift and ſubtile matter violently moved, by which the continuity of the nervous threads are deſtroyed. There is nothing in the idea of a ſharp ſound, from a cord of a certain length, that can inform the mind the ſaid cord trembles 5000 times in the ſpace of a ſecond. Neither does taſte teach us that the cryſtals of ſea-ſalt are of a cubical figure. Again, though a motion is impreſſed on the brain, from the ſenſation perceived by the body, the mind neither perceives this motion, nor the tremors of ſounds, nor the percuſſions of the rays of light, but ſomething perfectly diſtinct from this motion. But it is eſtabliſhed as a perpetual law by the Creator, that certain changes, made firſt in the nerve, and then in the common ſenſory, ſhall produce certain new correſponding thoughts in the mind, which have an indiſſolvable connection with each other; ſo that, although what we perceive in the world be arbitrary, yet that it is real, and not falſe, appears plainly from the perpetual agreement of ſimilar thoughts ariſing from ſimilar affections of the ſenſitive nerves, in all perſons at the ſame time, from one object, or in one perſon at different times.

DLVII. During the time of our perceptions, therefore, five very different beings are joined together: the body which we perceive; the affection of the organ of the ſenſory by that body; the affection of the brain ariſing from the percuſſion of that ſenſory; the change produced in the mind; and, laſtly, the mind's conſciouſneſs and perception of the ſenſation.

DLVIII. It appears from certain experiments, that the firſt origin of every perceiving nerve is always diſtinct; and that the change which is firſt excited by the external object in the ſaid nerve (DLVI.) continues in the origin of that nerve for a conſiderable time; and alſo that thoſe changes are ſo claſſed and laid up within the ſaid part of the brain, that thoſe are neareſt together, which were either contemporary, or nearly ſo, or which have ſucceeded next in courſe; or laſtly, which have a relation to the ſame ſubject, or were excited by ſimilar objects: inſomuch, that it is certain, new ſpecies or ideas are always conveyed again to the ſame part of the brain where others of the like kind are reſerved: for otherwiſe the arbitrary ſigns of words and letters would never be able to renew the ſame old ideas again in the memory; nor could diſagreeable ideas, returning into the mind, without the aſſiſtance of external objects, reproduce the ſame effects, as would the diſagreeable objects themſelves; nor, otherwiſe, could there be ſo conſtant and manifeſt a connection of analogous ideas, which moſt powerfully occur in dreams, according to the corporeal cauſes which then remarkably act in the brain. Whether or no do imagination and memory depend on this conſervation of ideas? Finally, thoſe changes in the ſenſorium, which many term paſt or reſerved ideas, are, for diſtinction's ſake, by us called the *footſteps* or *traces* of things, which are lodged or engraved not in the mind, but in the body itſelf, by certain notes or characters, incredible in their minuteneſs, and infinite in their number, recorded after an inexpreſſible manner in the medulla of the brain. Amongſt theſe characters, ſuch are more eminently and diſtinctly preſerved as were received, firſt by the ſight, and next by the hearing; for thoſe of the other organs are more confuſed and irrevocable by the will. And both the traces and their ſigns are preſerved; the latter more eaſily; the former, however, ſo far, that a painter can eaſily expreſs with his pencil upon canvas, an image of a face ſimilar to one which he is accuſtomed with, and which is impreſſed on his mind.

DLIX. *Imagination*, then, is whenever any ſpecies, preſerved in the common ſenſory, and in preſent perception, excites ſuch other thoughts in the mind as would ariſe if the perceiving nerve that gave the firſt birth to the ſaid ſpecies was itſelf affected or changed. This definition is confirmed by examples of the great ſtrength of fancy in certain perſons, and thoſe who are delirious; but in every body, in the inſtance of dreams, in which thoughts ariſe in the mind, occaſioned by the corporeal ſpecies reſerved in the brain, ſo as to be not at all weaker than thoſe which were firſt formed by the change in the ſentient nerve, from the external objects. Even more, the attention and reſt of the mind, with the abſence of all external objects, will often obtain a ſtronger aſſent from dreaming, towards the traces impreſſed in the brain, than that which is given from the mind by the perceptions which are excited from external objects: for the will is more powerfully determined in thoſe who dream, than in thoſe who are awake, ſo as often to perform certain actions by the voluntary muſcles, while they are aſleep, which they never can perform awake, even though the ſame nerves were more ſtrongly affected by the real objects. From hence we may underſtand, how it is poſſible the internal ſpecies, which are very ſtrong in a delirium, may ſo impoſe upon the mind, as to make her miſtake them for the perceptions of external objects; as, for example, in the fiery ſparks which are excited by preſſing the eye and optic nerve; in the redneſs ſeen by the eye when it is ſhut; in the vertigo or rotation that ariſes from a motion of the retina, which we aſcribe to the external objects themſelves; in the duplicity of ſight, &c.

DLX. But *memory* is, when any internal former thought of the mind, or the ſpecies perceived and preſerved in the brain, from external objects (CCCLXXII.), repeat or excite again other perceptions in the mind. And here the perceptions are commonly weaker than in the imagination, being almoſt only certain arbitrary ſigns conjoined together, with the idea that was firſt perceived in the mind: for the memory hardly repreſents the images and pictures of things to the mind; only the words or ſigns, and certain attributes, together with the general heads of ideas; for which reaſon, they move the will with leſs force: but it appears from the obſervation of thoſe changes which happen in the memory, that ſuch as ariſe from the external ſenſes remain longeſt in the brain; and ſometimes, if they made a ſtrong impreſſion, they may for ever, and in all ages of life, be repeated to the mind; but they are weakened, and in a manner blotted out in time, by degrees, unleſs the repreſentation be renewed again to the mind, either from an external object, or from the mind itſelf recalling the ſame change again into memory: ſo that, without this repetition, at laſt the change or impreſſion will be in a manner eraſed and quite loſt; and will never be able to be drawn in again to the mind, whenever ſhe repeats ſuch other thoughts as had naturally any connection with the former. This deſtruction of new and different ſpecies, conveyed to the ſenſorium, is evident, not only from the effect of time, but likewiſe from cataleptic diſorders; which ſometimes, after a conſiderable interval of time, go on with the ſame train of thought which the diſeaſe had interrupted. But ſometimes all of them will be ſuddenly deſtroyed by diſeaſe, in which the brain is any how compreſſed, either from the blood or other cauſes. Such a compreſſing cauſe, acting on ſome part of the common ſenſory, blots out a correſponding number of the ſpecies from the mind or memory, whether they be certain or all kinds of words, or even the characters by which we expreſs words; or, laſtly, the characters of our friends, and neceſſaries of life: yet all theſe ſpecies are often again renewable to the mind, whenever the compreſſing cauſe is removed. But the ſtrength and duration of an idea depends upon its being either unuſual, of a ſtrong action, or greatly conducing either to increaſe or leſſen our felicity; or, laſtly, from being joined with great attention from the mind, and often repeated: all which circumſtances being conjoined, may render the ſpecies ſo ſtrong to the mind, that ſhe will afterwards receive the perception of them, as if they came from external objects, in the manner we obſerve in mad people.

DLXI. Moreover, if we review the hiſtory of human life, it will appear, that in the beginning of our infancy, we have hardly any memory; only ſimple perceptions, that ſoon vaniſh: which, nevertheleſs, do for the preſent excite ſtrong thoughts or impreſſions in the mind, as we learn from the clamours of infants. But afterwards, the memory is perfected by degrees, and the ideas received from perſons moſt beloved and familiar to the infant remain impreſſed in the mind; while, at the ſame time, the imagination likewiſe increaſes in proportion, ſo as to be often very powerful in young children; as we ſee, for example, in frights, which in no age produce more violent or fatal effects. From thence forward, as the number of our ideas increaſes, the faculty of preſerving thoſe paſt, weakens; and, at the ſame time, the power of the imagination is more torpid or ſluggiſh: till at laſt the former almoſt periſhes, and the ideas, which are received but a ſhort time, eſcape from the brain; while, at the ſame time, the imagination, which is a kind of memory, languiſhes in proportion.

DLXII. But ſince the perceptions thus formed in the mind, produce in her various changes, which are perfectly free and diſtinct from any corporeal faculty, we ſhall briefly add ſomething concerning them, ſo far as may ſuffice to the purpoſes of phyſic. The office of *cogitation* in the ſoul, is to attend to the ſenſations which are either brought by the ſenſes, or recalled by the imagination; frequently alſo to the ſigns alone which recur into the mind. *Attention* then is ſaid to operate when the mind obſerves one and the ſame idea alone, and for a longer time together. The compariſon of two or more ideas brought to the mind, is called *reaſon*; as the ſimilitude, diverſity, or relation perceived by the compariſon, is called *judgment*. The principal cauſe of *wiſdom* and *invention* lies in a ſlow examination of the ideas, conſidered in the relation of all their parts one to another in the mind, while, neglecting all other objects, ſhe is employed with a ſtrong attention only upon that which is under examination. From hence proceeds that efficacy of ſolitude and darkneſs in making difficult calculation; with the more exquiſite attention of blind people to the nature of ſounds; and of thoſe who are deaf, to colours. The ſource of *error*, is ſome neglect in contemplating the whole idea, or the making an eſtimate of it from only a part of its note or character, or from a leſs congruous connection of ſome ideas with others that are diſtinct, but only related by accident, external cauſes, or affections.

DLXIII. The integrity or *ſoundneſs* of the judgment depends upon a perfect and healthy conſtitution of the brain [149]. For the fabric of the encephalon being changed,

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[149] In medical pſychology, differing only in a few remarks from that ſcience which is ſimply called *pſychology*, the actions of the ſoul or mind are inveſtigated. A more elegant ſubject, and more worthy of attention, cannot be imagined, than the thinking principle in man; whether we conſider the difficulty of the inveſtigation, the delight which the ſtudy of it affords, or the utility which it propoſes in life. It is a very well known point, that all bodies, endued with the perfect life which we uſually call *animal*, do not perform and exerciſe theſe functions of the mind in one and the ſame manner, degree of perfection, multitude of ſymptoms, and attributes, for the advantage of public ſociety, for the like and ſame reaſon, and, what ſeems peculiar to me, in the hope, knowledge, and remembrance either of future proſperity, or adverſity. All animals, quadrupeds and mammalia in particular, have ſome or other of the functions or operations of the mind in common with man: ſome ſeem to be proper to man alone, being bleſſed with the pleaſure of ſociety, and of education and ſpeech; but in men themſelves, there is in fact a wonderful difference both in theſe faculties and the exerciſe of the mind itſelf.

For although, among the various ways in which the human mind can act and exerciſe its own proper functions, and ſignify its government over the body, we confine ourſelves to two, we ſhall however obſerve ged, either by compreſſure, irritation, or a deficiency of blood, confounds all the uſe of reaſon; occaſions the ſtrong internal ſpecies of the brain to be repreſented to the mind as if they came from external or real objects; breaks the connection of the ideas, ſo that the

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ſerve a very great diverſity. Under this head belongs, (1.) The power of directing, exciting, and limiting the whole body, and many of the corporeal actions; whether our will be governed by inſtinct alone, which man frequently, though not always with ſafety, and brutes almoſt always indulge; or whether it be inclined by reaſon and underſtanding. (2.) The power of learning, of amplifying our knowledge, making new diſcoveries, meliorating human ſociety; and, in a word, of arriving at that pitch of felicity to which the divine wiſdom allows us to aſpire. The riſe and preſervation of ideas, the power of memory and imagination, and, by means of attention, the inherent bleſſing of thinking, comparing ideas, and paſſing judgment, &c. are all to be numbered in this claſs.

Upon rational conſideration, why theſe mental functions are exerciſed in ſo different a manner, both by men and brutes, a twofold claſs of cauſes is to be aſſigned; the one innate in the body; the other depending upon external cauſes, and their various methods of acting.

I. The firſt claſs of cauſes, allowing no change, unleſs in the moſt rare examples, ſuppoſes ſuch a conſtitution of the body, that is fit for performing its functions, and for receiving impreſſions from external cauſes. Of conſequence, in particular

a, Not only the preſence, but at the ſame time the due proportion, of the organs, muſcles, inſtruments, and certain viſcera is requiſite.

b, The neceſſary proportion of the brain and nervous ſyſtem to the whole body, and its parts in particular, and the interior aptitude of the ſame for performing its functions. Here we refer (1.) To the quantity and magnitude of the brain relatively to the whole animal body. Man has the largeſt brain among all the mammalia, a few excepted: compared with the weight of the whole body, 125 lib. it is $3\frac{3}{4}$, $4\frac{1}{2}$, 5 lib. and therefore proportionally as 30, or 26, or 24, to 1. The leaſt brain I ever ſaw was in a woman who was a great fool, and it was $1\frac{3}{4}$ to 100, the weight of the whole body. But in youth this proportion is changed, viz. the younger a perſon is, the more brain he has; in proportion almoſt as 1 to 8. The inference, therefore, that the powers of the mind increaſe with the greater quantity of brain, which the fœtus ſtate denies, is only conſiſtent with another attribute. (2.) To the different relation and proportion of each ſubſtance of the brain. The human brain is full of furrows and irregularly encircled portions. The younger man and all animals are, the more cortical ſubſtance is preſent, more than a the mind cannot compare them together; and is conſequently unable to judge of, or foreſee, their proportions, differences, or conſequences; ſtarting immediately from one idea to another that has no kind of relation: or laſtly, the actions of the ſenſes being either weakened or aboliſhed, and the brain in a manner deprived of its corporeal ſpecies, the man is reduced to the ſtate of an idiot or a plant. But the powers of external bodies alſo have a conſiderable influence in changing the ſpecies of objects which the mind acquires by the ſenſes; for the air, way of life, food, and cuſtoms, either help or diminiſh the ſoundneſs of the judgment, the force of the imagination, and the ſtrength of the memory.

DLXIV. Finally, as theſe ideas are either indifferent to us, or elſe conduce to the loſs and increaſe of our felicity,

a half of the whole: it is diminiſhed gradually as age grows up, and a great part of it is changed into medullary; which change, in fact, does not a little contribute to the increaſe of the mind. (3.) We muſt conſider the very ſpecific gravity of the brain in brutes and men at different ages. I have always found, and many obſervations have confirmed it, that a cubic inch of an infant's brain was ſpecifically lighter than the ſame of an adult; the ſame alſo held good of the more ſtupid ſort of men and quadrupeds. (4.) At the ſame time, we muſt remark the different proportion of the brain to the cerebellum; for moſt brutes have more cerebellum, with reſpect to the brain, than any man. It is the ſame caſe with the nerves. If you want a due perfection in this part of the body, you never can correct it, nor add any thing to the functions of the mind.

II. The latter claſs of cauſes comprehends thoſe bleſſings through which we acquire an increaſe of knowledge, and in general upon which the whole knowledge of man, our proſperous and adverſe fortune, &c. depend. We may reckon of importance here, *a*, The multitude of ideas which our ſenſes ſupply us with, and which we may augment by the imagination, memory, and aſſociation of ſimilar ideas. *b*, Our education, inſpired by our teachers; which, if it has been eaſy and faithfully taught us, wonderfully aids the rudiments of our underſtanding. *c*, The imitation of others; I would almoſt call it the primary cauſe of this claſs, the real ſource of proper and improper underſtanding.

We are unwilling to ſay more about the ſubject, though highly neceſſary; and indeed ſome of the moſt celebrated philoſophers have already begun to treat very accurately, and have advanced our ideas about it.

licity, ſo they produce different determinations in the *will.* Some of theſe ideas, by which the felicity of our mind is either increaſed or diminiſhed, ariſe merely from the mechaniſm of the perfect body: And amongſt theſe, corporal Pain is a ſorrowful ſenſe or perception in the mind, to which every violence or over-ſtrong ſenſation in any nerve ſeems to ſerve as a foundation; while Pleaſure conſiſts only in the nerves being irritated beyond what is uſual, but in a moderate degree. Itching ſtands related to pleaſure, inaſmuch as both of them have an increaſed flux of blood into the parts in which either the pleaſure or the titillation is perceived; but when increaſed, it tends towards pain, or to an over-violent ſenſe of the nerve. Anguiſh or anxiety is from an over-diſtenſion of the veſſels, becauſe the blood is hindered from paſſing freely through the lungs. The other ideas with which the mind is affected, are either wholly abſtracted from the properties of matter or body, or are at leaſt much leſs ſimple than the foregoing, which ariſe either from ſenſe or mechaniſm. The perception of good ideas excites joy; the deſire of poſſeſſing good excites love, as the expectation of it is the cauſe of hope: on the contrary, preſent evil cauſes ſorrowfulneſs, terror, or deſpair; the deſire of ſhunning evil excites hatred; and the expectation of a future evil excites fear. Hope, curioſity, and glory, ſeem to be affections of the human mind, which neither belong to the body, nor are to be found in beaſts.

DLXV. From theſe affections of the mind, the mere will appears not only to be determined to ſome foreſeen purpoſe, to which it directs the actions of the body, in order to poſſeſs good and avoid evil; but alſo in the body itſelf, unconſulted, and making no great reſiſtance, it exerciſes an equal dominion over the pulſe, reſpiration, appetite, ſtrength, affections of the heart, nerves, and ſtomach; with the changes which ariſe in the other parts, ſerving as ſigns of the paſſions in the mind, from which they immediately follow. Thus anger excites a violent motion of the ſpirits, cauſes a palpitation in the heart, a frequency of the pulſe, a greater ſtrength of the muſcles; urges the blood into the ſmaller pellucid and improper veſſels; and, laſtly, haſtens the expulſion of the bile from its veſſels; by which means it frequently removes obſtructions, or eaſes chronical diſeaſes. Grief, on the contrary, weakens the ſtrength of the nerves, and the action of the heart; retards the motion of the pulſe; deſtroys the appetite and digeſtion; whence it produces a paleneſs, cachexy, diarrhœas, jaundice, ſcirrhoſities of the glands, and other ſlow diſeaſes, ariſing from a ſtagnation of the humours. Thus, alſo, fear ſo much diminiſhes the force of the heart, as to occaſion polypuſes, paleneſs, and weakneſs of the muſcular motions, a palſy or relaxation of the ſphincters, an increaſe of inhalation, but a diminution of perſpiration. Terror from a preſent evil, will alſo increaſe the ſtrength to ſo great a degree, as to cauſe convulſions and a ſtrong pulſe; whence it ſometimes removes obſtructions in palſies, or, by intercepting the courſe of the blood, it kills ſuddenly. Love, hope, and joy, promote the perſpiration, quicken the pulſe, and give the blood a free circulation; whence they increaſe the appetite, and render diſeaſes curable. But exceſſive and ſudden joy often kills, by increaſing the motion of the blood, and exciting a true apoplexy. Shame, after a peculiar manner, retains the blood in the face as if the veins were tied; it will alſo ſuppreſs the menſes or other ſecretions, and in ſome caſes has even produced death.

DLXVI. But in what manner are theſe changes produced, from the commotion of thoſe paſſions in the mind? Do not the nerves cover the veſſels like ſphincter muſcles, ſo as, by contracting them ſuddenly, to increaſe the courſe of the blood, or, by relaxing and weakening their tone, retard and vitiate the circulating juices? That this is the caſe in the ſmaller veſſels, appears evidently from the near ſimilitude of effects from fear and cold upon the nerves of the ſkin. But in the genital parts, from a conſtriction of the veins, under particular circumſtances, we perceive that the blood is manifeſtly collected or accumulated in the parts: and it is no leſs probable, that, even in the larger veſſels, the nervous bridles with which many of them are ſurrounded, produce the ſame effects: for thus, in ſeveral parts, they ſurround and include the meningal, temporal, vertebral, carotid, ſubclavian, cœliac, meſenteric, renal, and other arteries. But after it is ſhown by our experiments, that the nerves are at reſt during the action of the muſcles, nor can be rendered ſhorter by any irritation, we muſt deſert this elegant theory[150]. Nor does it ſeem far from the truth, that the arteries are rendered more or leſs irritable from the various ſenſibility of the nerves, and thus may be contracted more vehemently or languidly by the ſame quantity of blood: and thus the motion of the blood is either quickened or ſlackened, if it is at all certain that the ſmaller arteries have the ſame irritable nature which is common to the large ones. And thus it is that the appetite and periſtaltic motions of the alimentary tube are manifeſtly deſtroyed or depraved by the paſſions of the mind.

DLXVII. Nor is it to be denied, that the Creator has affixed certain characteriſtic marks or evident ſigns to the paſſions of the mind, that in mutual ſociety one man might not impoſe upon another. For the reſpective muſcles, more eſpecially of the voice, face, and eyes, do naturally expreſs the ſeveral paſſions of the mind, ſo faithfully, that they may be even repreſented by a painter. To run through them all would indeed be an elegant theme, but too long for this Compendium. From the actions of theſe muſcles, often repeated by the affections, follow the features or phyſiognomy

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[150] From ſeveral and new anatomical reaſons, I am inclined to embrace the author's former opinion; nor could he himſelf perhaps ever have abandoned it, had not the confuſion ariſing between irritability and ſenſibility, which he dreaded from that aſſertion, determined him to eſpouſe the contrary.

ſiognomy[151] of a perſon's face, which is a perpetual index to the ſtate of the mind, and retains ſomething of the action of the prevailing muſcles; ſo that the appearance of anger often remains in the countenance, after the paſſion itſelf is gone off.

LXVIII. From whence proceeds the conſent of parts, which is ſo famous and often repeated by writers on the practice of phyſic? Some of them appear to depend upon the conjunction or inoſculation of the blood-veſſels; by which the blood being driven out of one, is more ſtrongly urged into another veſſel, which has its branches from the ſame common trunk. To this cauſe belong the revulſions made by blood-letting, the pains of the head which enſue from a cold in the feet, &c. In other parts, the conſent ariſes from a ſimilitude in their fabric, by which they ſuffer like effects from the ſame cauſes in the body: to this alſo we refer the conſent that is betwixt the womb and the breaſts. Another cauſe of this conſent is a continuity of the membranes, extending from one part to another: from hence a ſtone in the bladder excites an itching in the glans of the penis, a diarrhœa cures a deafneſs ariſing from a defluction. Another cauſe of conſent lies in the nerves themſelves, and their anaſtomoſes or communications one with another, as appears plainly from the teeth being ſtupified or ſet on edge by certain ſounds, becauſe the various communications which the hard portion of the auditory makes with the maxillary nerve transfers the diſagreeable ſenſe to the latter. Thus alſo, the ſympathy of the eyes, which is not obſervable in like manner in the ears, proceeds from the mutual conjunction of the optic nerves within the ſkull; and thus a ſtone in the kidney excites vomiting. Laſtly, the conſent may proceed from ſome cauſe acting on the common ſenſory, and beginning of the nerves; whence the irritation of a ſingle nerve manifeſtly excites ample convulſions, ſpreading through the other parts: ſo an univerſal epilepſy will proceed from a local diſorder, &c. A conſent is obſerved, in ſome diſeaſes, from a tranſlation of the matter of a diſeaſe by filtration through the cellular ſubſtance of one part to another; and another kind proceeds from the incumbent weight or actions of the adjacent muſcles and arteries.

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[151] It is a dangerous, and too deceiving ſtep, to give a deciſion from a reliance on the phyſiognomy. I reckon Camper the beſt judge of this ſubject, who ſhould be conſulted for his ingenious remarks. He muſt underſtand the rules of art, the good and bad diſpoſition of men, the characters of nations and the genius of brutes, who wiſhes to write with any ſort of authority upon the ſubject. However, there is in the muſcles of the face a certain declaration, given by the words and ſigns, of a good or bad ſtate of mind, which never will deceive a ſkilful perſon; but may be wonderfully diſguiſed by thoſe addicted to lying. *Fronti nulla fides, nimiumque ne crede colori.*

DLXIX. But there is ſtill another remarkable conſent to be explained betwixt the body and the mind. For that the nature of the mind is different from that of the body, appears from numberleſs obſervations; more eſpecially from thoſe abſtract ideas and affections of the mind which have no correſpondence with the organs of ſenſe. For what is the colour of pride? or what the magnitude of envy or curioſity? to which laſt there is nothing ſimilar in brute animals; neither can that happineſs which is deſired by it, *viz.* the glory of new ideas, be referred as an acquiſition to any corporeal pleaſure. For is it poſſible, that a body can acquire two kinds of forces by the uniting of an infinite number of ſmaller parts into one maſs; each of which ſhall not only preſerve their own particular properties and affections, and repreſent themſelves, but alſo join together into one conſcious whole, differing from all the characteriſtics of its component parts, and yet be capable both of perceiving and comparing the attributes of thoſe parts? Is there any one inſtance of a body, which, without an external cauſe, can, like the mind, paſs of itſelf from reſt to motion; or is there any body that can change the direction of its motion, without the action of ſome other cauſe? Upon ſlight reflection, it will be obvious to all, that voluntary action is the attribute of the mind alone.

DLXX. Yet the mind, however different from the nature of the body, is cloſely tied to the ſame, under certain conditions; ſo that ſhe is obliged to think upon thoſe ſpecies which the body offers to her perception; and again, ſo that ſhe cannot perceive, remember, nor judge, without the repreſentation of thoſe corporeal ſpecies, which are lodged in the brain: and again, her will is the cauſe of the greateſt and ſwifteſt motions in the body.

DLXXI. Thoſe have behaved modeſtly who, confeſſing themſelves ignorant as to the manner in which the body and mind are united, have contented themſelves with proceeding no farther than the known laws which the Creator himſelf has preſcribed, without inventing and ſupplying us with conjectures not ſupported by experience. We may, ſurely, be excuſed in this reſpect from the obſervation (DLVI.), which is here equally certain as in optics, that the affections of bodies cohere, by an arbitrary relation or connection, with the thoughts of the mind; in ſuch a manner, that they would produce thoughts of a different kind, if the Creator was to alter the figure, the refracting power, or colours of the parts of the eye. Thus he has eſtabliſhed a law, which obtains always, betwixt the leaſt refrangible rays and a red colour, or an idea of ſuch in the mind: and thus there is a law betwixt the impreſſion of thoſe rays upon the retina, and the connection with the correſponding thought. Nor need we be more aſhamed to confeſs our ignorance in the mechaniſm of this law in the effects of nature, than we are to own ourſelves unacquainted with the nature of the former.

DLXXII. But it will perhaps be demanded of us, Whether the mind does not govern the whole body? and whether or no all the motions and actions in the body do not ariſe from the mind, as the immediate ſpring and principle of motion? Whether even the motion of the heart, arteries, and reſpiration, does not ariſe from the mind, conſcious, and ſolicitous for the common good of the whole ſyſtem? Whether this power of the mind does not appear in the ſtopping of hemorrhagies from wounds, by grumous concretions; to which add, the force of paſſions of the mind, and the power of the mother's imagination, in the marking or other blemiſhes of infants? Whether the abſence of conſciouſneſs in the mind, with reſpect to theſe defects, be not excuſable, from the known obſcurity of attention which ſhe gives to the reſpiration, the motion of the eye-lids, and muſcles of the eye itſelf, the ear, or tongue; all which motions, we know, are effected by the will, although we know not the organs, nor take any notice of the action of the will, when we breathe, look, hear, or even walk, while we are taken up with other thoughts? Whether or no is it certain, that all bodily motions ariſe from the mind, on the account of our being unable to find out any other cauſe, conſtantly united to the body, to which we can manifeſtly refer them?

DLXXIII. There are indeed many reaſons which will not permit us to conſent to this opinion. And, firſt, the conſtruction and government of the body itſelf appear greatly to exceed all the power and wiſdom of the mind. The mind is able to ſee but one point diſtinctly at a time (DLV.), and it can entertain only one thought or idea at once: for if it endeavours to ſee two objects at a time, to contemplate two different ideas together, or read two letters at once, the ſenſe of both is immediately confuſed, the mind ſtrays in her reaſoning, and makes no right judgment of either object; inſomuch, that being ſenſible of this her weakneſs, whenever ſhe endeavours to make a ſerious and diligent inquiry into any object or intended work, ſhe withdraws herſelf, and ſhuts up all the ports of ſenſe, without taking any impreſſions either by the ſight, hearing, ſmelling, &c. or without exerciſing any of the voluntary motions of the muſcles. But the mind ought to be capable, not only of infinite thoughts, but alſo diſtinct ones, ſo as to be able to perform and govern ſo many hundred muſcles, organs, veſſels, and moving fibres, in ſuch a variety of ways, and with ſo great an exactneſs, as is difficult to, or even above all the ſolutions that can be given by the working of geometrical problems: and yet, by this hypotheſis, the mind, ignorant both of herſelf and of her works, ought not only to be equal to ſo immenſe a taſk; but likewiſe, at the ſame time, ſhe muſt, over and above thoſe works, be capable of contemplating the moſt difficult and abſtracted ideas, without either diſturbing her meditations by the cares which concern the body, or neglecting any of her neceſſary corporeal offices by the variety of her mental operations.

DLXXIV. Moreover, if, without being conſcious of our will, we are nevertheleſs able, by that faculty, to influence the reſpiration, the winking of the eyes, &c. and even to be able not only to govern, but alſo to ſuſpend our breathing, ſhut or cloſe our eyes, and open them again; it follows from thence, that we never loſe either the conſciouſneſs or the uſe of thoſe actions, and conſequently neither the government of them. But we are able to perform nothing of this kind in the heart or inteſtines; we cannot reſtrain the motion of thoſe parts when they are too quick, nor excite them when they are too languid. In ſuch a number of perſons as inhabit the world, why do we not meet with ſome who can govern the motion of their guts? Or why, in all the ages of the world, not one who could govern the contractions of the heart? If cuſtom only is the cauſe of this unknown power, why does not the mind receive a ſenſe of her action, in moving the heart, after it has ſtood ſtill for whole hours, or even days, in ſwoons, in hyſteric fits, and in perſons drowned?

DLXXV. But it is evidently a falſe poſition, that all the motions of the body ariſe from the mind, without which the body would be an immoveable unactive maſs: for the force of muſcular contraction, by any kind of ſtimulus, to which the motion of the heart, inteſtines, and perhaps all the other motions in the human body are obedient (CCCCXCI.), does not require the preſence of the mind; ſince that power continues a conſiderable time in a dead body, and may be recalled again into action by mechanical cauſes, as heat, inflation, &c. Nor does this power deſert the fibres ſo long as they continue unſtiffened by cold, although the mind may have been a long time ſeparated from the body by a deſtruction of the brain: and this action we ſee more evidently in the heart, after that muſcle has been taken out of the body for ſome time, ſo as to be ſeparated from any imaginable connection with the mind.

DLXXVI. As to the blemiſhes of infants, we have declared in another place, how little that article is to be depended on. The adminiſtration of the vital motions, in diſeaſes, is not under the rule of any prudence, but governed almoſt entirely by the power of ſtimulus; as we are manifeſtly taught from the moſt ancient and only certain practice, by which we are directed to reſtrain the too great violence of theſe motions in acute and intermitting febrile diſeaſes, by the uſe of blood-letting, with the poppy, nitre, Peruvian bark, &c. The wiſeſt philoſopher in the world has no more privilege or advantage in the government of his body, than the mereſt idiot; and that a fœtus, when it is born, has not ſufficient knowledge how to move its muſcles, but by experience learns to go, prattle, ſee, and, finally, to rear up its own body, which is formed with incredible art, is indeed an aſſertion ſo void of probability, as is ſufficient to refute the hypotheſis.

DLXXVII. A ready diſpoſition to the exerciſe of ſenſe and voluntary motion, in healthy organs, is called *vigilance* or *wakefulneſs;* but an indiſpoſition to ſuch an exerciſe of them, with an inclination to reſt, in all the ſaid organs, while they remain healthy and entire, is called *ſleep.*

DLXXVIII. In ſleep, the mind either thinks not at all of what ſhe knows or retains in memory; or elſe ſhe only attends to the traces of paſt objects repoſited in the common ſenſory (DLVIII.); the vivid repreſentations of which excite altogether the ſame perceptions as are made by the impreſſion of external objects upon the organs of ſenſe, by which they were firſt received. Theſe repreſentations of ſpecies to the mind are called *dreams;* and happen whenever a ſmall portion of the brain or common ſenſory is, by the refluent motion of the ſpirits, kept in a ſtate of vigilance, while all the reſt of the empire of ſenſe and voluntary motion is ſilent and at reſt. Sometimes there are certain voluntary motions, following of courſe from the perceptions thus perceived by the mind, ſuch as ſpeech, or motion of all or ſome of the limbs, conformable to the nature of what the mind perceives; and hence ſome walk in their ſleep.

DLXXIX. But, during the time of ſleep, the motion of the heart, with the diſtribution and circulation of all the other humours in the body, are regularly continued, together with the periſtaltic one of the ſtomach and inteſtines; and, finally, the action of the ſpincter muſcles, with the reſpiration, are continued in a like manner. This compoſition, in which a certain number of the organs are at reſt, while others continue their motions, renders a knowledge of the mechanical cauſe of ſleep ſomewhat difficult to attain.

DLXXX. Therefore, in order to make this diſcovery, with all its cauſes, we ſhall conſider all the appearances both of ſleep and vigilance, and trace them in all kinds of animals; for that condition which appears conſtantly to follow from all thoſe cauſes and appearances, will be the true and mechanical cauſe of ſleep. Sleep naturally follows after the vigilance and labour which are joined to human life. For when a perſon is awake, there is a continual motion or exerciſe of the voluntary muſcles, of the parts which guard the ſenſes, and of the affections of the mind; all which continually add a new ſtimulus to the nerves, blood-veſſels, and heart itſelf. Thus the blood, by continual motion and triture, changes its ſmooth albuminous nature, to a rough alkaline, and in ſome degree putrid, ſharpneſs; while, at the ſame time, its more fluid parts, eſpecially thoſe ſubtile ones which compoſe the nervous ſpirits, are diſſipated faſter than they are ſecreted; whence gradually enſues both a weakneſs and a wearineſs of the body: and, if the vigilance be continued longer than uſual, there is alſo a feveriſh heat, a greater acrimony of the humours, and a ſenſible loſs of ſtrength. As the night advances, a weight or heavineſs ſeizes all the large muſcles and their tendons, the mind becomes unfit for any accurrate thought or ſtudy, and ſeeks after reſt. Hereupon the powers which hold the body erect, ſhrink from their office, the eye-lids cloſe, the lower jaw falls down, a neceſſity of yawning comes on, the head nods forward, and by degrees we take leſs notice of the external objects, till at length all the thoughts and ideas are in confuſion, and a ſort of delirium enſues; from whence there is a tranſition to ſleep not ſufficiently marked, which however always precedes ſleep. In this natural ſleep, which is common to all animals, the cauſe ſeems to be a deficiency of the nervous ſpirits, which have been every where largely conſumed by the exerciſes of the muſcles and ſenſes, in whoſe actions there is probably a great quantity of this fluid exhaled.

DXXXI. A perfect reſt or compoſure of the mind and external ſenſes, with the abſence of all ſtimulus or irritation in the head and other parts of the body, joined with darkneſs, promote and haſten the forementioned ſteps of ſleep, and render it more quiet or profound.

DLXXXII. Again, it is obſervable, that a variety of cauſes, which weaken the powers, incline to and increaſe ſleep; ſuch as great loſſes of blood from any cauſe, bleeding from a vein, the uſe of cooling medicines or thoſe prepared from the poppy, and cold of the external air; to which add, ſuch as call off the quantity of blood flowing to the head, as warm-bathing of the feet, a plentiful ingeſtion of food into the ſtomach, which is found to produce ſleep in all kinds of animals.

DLXXXIII.

DLVIII. On the contrary, again, there are various hot medicines which induce ſleep, by exciting a greater afflux of blood to the brain; ſuch as wine, alcohol, or vinous ſpirits of all ſorts, but more eſpecially when reſolved into vapour; opium, hyoſcyamus, the indigeſtible particles of our aliments; to which add, acute and malignant fevers of various kinds, or elſe ſuch things as retard the return of the venous blood, as fatneſs. All theſe cauſes ſeem to concur in this, that the blood being collected in the head, compreſſes the brain, ſo as, in a degree, to intercept the courſe of the ſpirits from thence into the nerves.

DLXXXIV. But likewiſe mechanical cauſes produce a ſleepineſs; namely, a compreſſure of the dura mater and brain, whether from extravaſated blood, a depreſſed part of ſome bone, or a collection of ſerous water within the ventricles of the brain itſelf.

DLXXXV. Sleep, therefore, ariſes either from a ſimple deficiency of the quantity and mobility of the ſpirits, or a compreſſure of the nerves; but always from a more difficult motion of the ſpirits through the brain.

DLXXXVI. This theory is likewiſe confirmed by the cauſes of vigilance: for all thoſe things prevent ſleep which produce plenty of ſpirits; more eſpecially warm aromatic drinks, which ſend plenty of minute ſtimulating particles to the head, by which the motion or courſe of the blood is moderately quickened through the brain; and, being at the ſame time more dilated, makes a larger ſecretion of ſpirits in a given time.

DLXXXVII. Sleep, again, is hindered by cares of the mind, meditation, ſtudy, and paſſions of a ſtronger degree, with pains of the body and mind; all which hinder the ſpirits from reſting in the common ſenſory, or urge them ſo as to prevent the nerves from collapſing. Therefore, as the former increaſe the quantity of the ſpirits, theſe cauſes increaſe their motion. And therefore, again, the ſame concluſions are to be made from hence as before (DLXXXV.); namely, that the nature of ſleep lies in a collapſing of the nerves which go out from the common ſenſory.

DLXXXVIII. If it be inquired, Whether the ſeat of ſleep be not in the ventricles of the brain? we anſwer, that it is not conſiſtent with the ample bounds or dominions of ſleep, which extends itſelf even to ſuch animals as have no ventricles in the brain. Whether do the vital actions continue to be carried on in ſleep, as it is only an affection of the brain independent of the cerebellum? and what may be the cauſe of this difference, by which the animal offices reſt in ſleep, while the vital operations are continued? We know not of any other reaſons, beſides thoſe before given, that the vital motions are perpetually ſtimulated into action, from the cauſes urging a neceſſity of keeping them from reſt (CCCXCII.)

DLXXXIX. The effect of ſleep is a moderation or abatement of all the motions in the human body. For now the action of the heart only remains, by which all the humours are ſent through the veſſels, at the ſame time that all the muſcles and perception of the nerves, with the paſſions of the mind and voluntary motions, are diſcontinued; by which, independently of the heart, the courſe of the ſpirits was quickened, ſo as to cauſe wakefulneſs (DLXV. CCCCXVII.) Thus the heart, is gradually reſtored from its quick and almoſt feveriſh pulſation, to the ſlow and calm condition in which we find it in the morning; the breathing in ſleep becomes ſlower and ſmaller, the periſtaltic motion of the ſtomach and inteſtines, the digeſtion of the aliments, the ſenſe of hunger, and the progreſſion of the fæces, are all diminiſhed; at the ſame time, the thinner juices move more ſlowly on, while the more groſs and ſluggiſh are collected together, and the fat being poured out is accumulated in the cellular ſubſtance; the viſcid albuminous humour, for the nouriſhment of parts, adheres more plentifully to all ſides of the fibres and ſmall veſſels; the conſumption of the ſpirits, the attrition of the blood, and the quantity of perſpiration, are all diminiſhed. Thus, while the quantity of the nervous ſpirits continues to be ſecreted, with a leſs conſumption, it is by degrees accumulated in the brain, ſo as to diſtend and fill the collapſed nerves, that, both in the internal and external organs, return to action by the approach of ſome ſmall ſtimulus, by which they are reſtored to vigilance. Sleep, continued for too great a length of time, diſpoſes to all the diſorders that attend a ſlow circulation, to fatneſs, drowſineſs, weakneſs, and cachexies; and is, at the ſame time, highly detrimental to the memory.

DXC. From whence does yawning attend thoſe that are about to go to ſleep? We anſwer, To promote the paſſage of the blood through the lungs, which is now ſlower. Whence the ſtretching of the limbs? To increaſe the motion of the ſpirits, that they may overbalance the natural contraction of the muſcles, by which all the limbs are drawn into a moderate degree of contraction. If it be demanded, From whence came the unjuſt opinion, which has been ſo well received, that the motion of the heart becomes ſtronger in ſleep, and the perſpiration more plentiful? we anſwer, That the miſtake aroſe from the increaſed heat ariſing from the bed-cloaths, by which the perſpirable matter being confined, every where conduces to warm, ſoften, and relax the ſkin. But any one that ſleeps in his uſual garments grows colder; and animals which ſleep for a long ſeaſon together grow cold externally to the higheſt degree, as field-mice and hedge-hogs. From whence is it that all animals grow ſleepy after taking food? Not from a compreſſure of the aorta, or from a repletion of the head with blood; for even animals which have ſcarce any brain ſleep after food. Whether or not do the indigeſtible particles of our aliments, by paſſing leſs eaſily through the brain, and compreſſing its medulla, produce ſleep of a leſs benign kind? Whether or not is there a perpetual dreaming, ſo as to be inſeparable from ſleep? and whether this be natural, ſo that the mind never ceaſes to be without thought, as a conſequence

ſequence following from ſenſation? We anſwer, This does not ſeem to be the true ſtate of nature; for dreams we judge to be rather referable to diſeaſe, or to ſome ſtimulating cauſe that interrupts the perfect reſt of the ſenſorium. Hence that ſleep refreſhes moſt in which there are no dreams, or at leaſt that in which we have no remembrance of any. Hence they are generally wanting in the firſt ſleep, at which time the ſpirits are moſt exhauſted, and return in the morning when theſe are in ſome meaſure repaired. Hence we ſee, that intenſe cares of the mind, or the ſtrong impreſſion of ſome violent idea received in the memory, hard indigeſtible food abounding in its quantity, with any uneaſy poſture of the body, are the moſt uſual cauſes that excite dreams; for they are uſually generated by ſome ſenſation which, by the law of aſſociation of ideas, joins with itſelf a whole collection of ſpecies having an affinity with that one.

CHAP. XIX.

Of MASTICATION, SALIVA, and DEGLUTITION.

DXCI. SUCH hard and tough foods as conſiſt of long parallel fibres, or are covered with a bony ſhell or cartilaginous ſkin, generally require maſtication, to divide them into leſs cohering parts, that they may more eaſily yield their nouriſhment to the diſſolving powers of the ſtomach. The more diligently they are ſubdivided in the mouth, the more reliſhing and agreeable they become to the ſtomach; the nearer they approach to the nature of a fluid, and the more eaſily are they digeſted or aſſimilated.

DXCII. Therefore moſt animals are provided with teeth, extremely hard, with a root that is indeed bony and hollow; ſince it receives, through a ſmall hole in the tip or point of each fang, little blood-veſſels, and a nerve, which go to form its internal perioſteum [152]:

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[152] There is no part of our body we are better acquainted with than

and this whole root, being fixed into a ſocket of the jaw conformable to itſelf, is, in the upper part towards its crown, ſtrongly ſurrounded and tied down by the adhering gum. But the crown, or upper part of the tooth, placed above the gums, is not bony; but a peculiar ſort of enamel, of a harder, denſer ſubſtance, and almoſt of a glaſſy texture, compoſed of ſtraight fibres vertical with its root, and running together towards the middle. This laſt portion of the tooth, having neither perioſteum nor veſſels, perpetually grinds away, and is as often repaired again by a kind of petrifying juice, that aſcends or filtres from the cells of the root; by which mechaniſm they are therefore ſupplied with a great degree of hardneſs, very fit to overcome that of other bodies, and to grind the food with their unequal ſurfaces.

DXCIII. As the materials of our food are various in their texture and firmneſs, nature has accordingly made our teeth variouſly figured. In us, the anterior or inciſive teeth are four in each jaw, weaker than the reſt, and fixed by a ſingle root, upon which ſtands a crown

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than the teeth, both with regard to their riſe, ſtructure, and changes, and their diverſity in different animals, uſe, and diſeaſes. A few remarks remain, which have eſcaped the induſtry of Janck, Albinus, and the celebrated Hunter, and which future experience may ſuggeſt. I ſhall add a few. The teeth which firſt appear; I mean the four inciſores of both jaws, the two canini and the four molares, lie hid in a canal or capſule, ſupplied with an artery and vein: theſe run the whole length of the canal; in the lower jaw below the teeth, in the upper above them; and every tooth ſends off as many branches as it has roots. All theſe veſſels are diſtributed through a membrane which encompaſſes the ſhooting tooth. The veſſels retain the ſame trunk; although, the tooth being ſenſibly formed, the prolonged root at length leaves a ſmall hole, which the plexus of the tooth's artery, vein, and nerve enters. Any tooth which is about to come out is incloſed in its own membranous ſack, elegantly ſet with veſſels; which net-work, in my preparations, I cannot but admire, forming its internal and external perioſteum. The moſt tender nervous filaments enter the ſame ſac with the veſſels, and terminate in the cellular ſubſtance, leaving no viſible proof that the nerves are intermixed with the oſſeous ſubſtance.

crown inwardly concave, outwardly convex, and terminated by a gradual extenuation, like a wedge or chiſel, with a rectilineal edge. The office of theſe is only, in the ſofter foods, to cut thoſe which are tougher than the reſt into ſmaller portions; ſuch as the fibres and membranes of animals and vegetables, with the brittle ſeeds and kernels of fruits.

DXCIV. The ſecond ſpecies is the *canine teeth*, which are two only in each jaw, fixed by a longer and ſtronger, but ſingle root; from whence their crown is extenuated into a cone. Theſe lacerate tough aliments, and hold faſt ſuch as require a longer triture by the grinders.

DXCV. The third order of the teeth is that of the *molares*, which in general are compoſed of ſeveral roots, with a quadrangular crown, ſomewhat flat ſurfaced, but more or leſs divided by rocky aſperities. The two foremoſt of theſe are weaker than the reſt, inſerted by two, or often but one root, with the ſurface of their crown parted into two; but the three poſterior grinders are larger, fixed by three, four, and ſometimes five roots, but terminated in their crown by only one ſurface, ſomewhat ſquare and flat, but leſs in the lower than upper jaw, and is ſubdivided into a number of eminences correſponding to that of their roots. Betwixt theſe teeth, the moſt compact or bony foods are interpoſed and broke, as the more tough and hard are ground ſmaller, while the lower teeth are urged obliquely and laterally againſt the moveable upper ones; and theſe are the teeth which perform principally what we are to expect from maſtication of food.

DXCVI. That the teeth might break or grind the food with due ſtrength and firmneſs, the uppermoſt are fixed into the ſockets of the immoveable upper jaw, as the lower ones are into the lower moveable jaw, which is a ſingle bone, and ſo joined with the temporals, that it may be drawn down from the upper jaws, and pulled up againſt them with a great force; and may be moved laterally to the right or left, forward and backward,

ward. Thoſe various motions of the lower jaw depend upon the articulation of its oval heads, in which the lateral parts of the jaw terminate, convex or higheſt in the middle, and received betwixt the oblique protuberances of the temporal bones, in a ſhallow excavation, at the root of the jugal proceſs, deeper in its middle; and increaſed by a little excavation of the ſame kind before the auditory paſſage, from which it is ſeparated by a peculiar fiſſure. This joint has the freer liberty in moving, and its incruſtated cartilages have a longer duration, by the interpoſition of a ſmall cartilaginous plate, betwixt the condyle of the jaw and tubercle of the temporal bone; concave in its middle above and below, with riſing ſides, which ſurround the tubercle of the temporal bone upward, the condyle of the jaw downward, and correſponds to the adjacent inequalities.

DXCVII. The muſcles moving the lower jaw, which are weak in man, but very ſtrong in brute animals, are the *temporalis* and elevator, ariſing from a large part of the ſide of the ſkull, and from the outward tendinous expanſion of it the ſtellated fibres run together into a tendon fixed to the ſharp proceſs of the jaw; the *maſſeter* elevator, having two or three diſtinct parts or leſs muſcles, deſcends from the os jugalis and margin of the upper jaw backward into the angle of the lower jaw. Both theſe act in concert; but the temporal muſcle brings the jaw more backwards, and the maſſeter forwards. The *pterygoideus internus* deſcends from the pterygoide foſſa, and from the palate bone and root of the little pterygoidal hook, with the internal wing, into the angle of the lower jaw, which it elevates or draws to one ſide or the other alternately. The *pterygoideus externus* has a double origin; one tranſverſe from the inner wing and adjacent bone of the palate, with the poſterior convexity of the upper jaw: the other, deſcending, ariſes from the hollow temporal part of the great wing of the ſphenoides; thence it proceeds backward and downward into the outer part of the condyle of the lower jaw, which it moves laterally, and draws forward before the upper jaw.

DXCVIII. The lower jaw is depreſſed, ſo as to open the mouth by the digaſtric or *biventer* muſcle, ariſing from an hollow of the maxillary bone; from whence deſcending, its middle tendon is tied by a firm cellular ſubſtance of a tendinous nature to the os hyoides; and being likewiſe connected to the mylohyoideus, and then paſſing through the divided fibres of the ſtylohyoideus, it is increaſed by another fleſhy belly, inſerted at the ſymphyſis of the two halves of the lower jaw, within the chin. Moreover, the mouth may be partly opened by all the other lower muſcles of the jaw, os hyoides, and the larynx, as the geniohyoideus, geniogloſſus, ſternohyoideus, ſternothyroideus, coracohyoideus, and latiſſimus colli; although the latter rather draws the ſkin of the neck and face downward than the jaw itſelf. The geniohyoideus and digaſtric muſcles have a power of drawing the jaw backwards.

DXCIX. The lower jaw is elevated with a great force, ſo as to divide the food by the preſſure of the upper and lower teeth againſt each other, by the action of the temporal maſſeter, and internal pterygoide muſcles; the contraction of which appears by experiments to be very powerful, and ſufficient to raiſe ſeveral hundred weight. The lateral and circular motions of the jaw upon one of its immoveable condyles are performed by the external and internal pterygoidei, acting either alone or together with the former. Thus the food is cut, lacerated, and ground to pieces; and if the maſtication be continued diligently, it is together with the liquors of the mouth, reduced into a kind of pulp.

DC. The fore-part of the teeth is covered with a cutaneous and fleſhy ſack, which is every where produced from the integuments of the face; and makes a hollow, in which both rows of teeth are ſhut up. The ſides are called the *cheeks*, the middle parts the *lips*. From this cavity there lies a paſſage, betwixt the teeth, into the mouth; which on the upper part is bounded by the bony and ſoft palate, underneath by the fleſhy parts lying under the tongue, and on the fore-part by the teeth. On the back part it opens between the ſoft palate and tongue into the fauces. The tongue divides the cavity of the mouth in the middle, and is eaſily moveable to every part of it.

DCI. During the trituration of the food in the mouth, there is continually poured into it a large quantity of a watery clear liquor, evaporable or inſipid, or at leaſt but very little ſaline, and containing but little earth; neither acid nor alkaline, although from thence may be obtained a very ſmall portion of lixivial ſalt; of which there are numerous ſprings in the neighbourhood. A large quantity of this *ſaliva* is ſeparated by numberleſs ſmall glandules of the lips and cheeks, of an oval figure, and ſome larger ones which are placed round the mouth of the duct of the parotid gland; and laſtly, the pores of the hard palate pour out this liquor, which they ſecrete, through a little ſhort duct and hole. The juice poured out from the exhaling veſſels of the tongue, mouth, and cheeks, is of the like kind, or rather more watery. As for the ductus inciſivus, we are now ſufficiently certain that it is blind, or diſcharges nothing into the mouth, only gives paſſage to an artery from that of the palate into the nares.

DCII. The ſaliva is a watery liquor, with a moderate quantity of ſalt, partly lixivial, and partly culinary; with ſome oil and earth, diſſipable by the fire; with ſcarce any taſte, unleſs given to it by diſeaſe or famine, The quantity produced is very conſiderable, as twelve ounces have been known to flow out from wounds in thoſe parts in the ſpace of an hour. By good-mannered people it is for the moſt part ſwallowed; and uſefully, as it cannot be thrown away without hurting the digeſtion.

DCIII. But the ſalival glands eſpecially ſupply the watery humour called after their own name. Of theſe the principal is the parotid, filling up a large interval be-

betwixt the auditory paſſage and the lower jaw, to which it is immediately contiguous in the part uncovered and to the maſſeter. It is a conglomerate gland, made up of round or grape-like cluſters, connected by the cellular ſubſtance; which laſt, being denſified and reticulated, forms an almoſt tendinous covering that ſurrounds and connects the whole gland. Its duct is white, vaſcular, and capacious, aſcending from the bottom of the gland to the os jugale, from whence it is tranſverſely inclined, and takes in by the way a ſmall duct of a ſolitary glandule on the top of the maſſeter, or elſe lodged diſtinct, or continued upon the parotid itſelf, and is rarely double; after this the duct, bending round the convex edge of the maſſeter, opens with an oblique or cut aperture, without a papilla, through the departing fibres of the buccinator muſcle, in the midſt of many little glandules of the cheek. The bulk of this gland, and the number of its arteries, make it the chief ſpring from whence the ſaliva flows.

DCIV. Another ſmall gland, adjacent to the parotid, but twice as little, compoſed of ſofter and larger kernels, connected by the like cellular membrane, is, from its ſituation at the lower angle of the jaw, called *maxillary;* being in part terminated only by the ſkin, but in part ſends off an apendix over the mylo-hyoide muſcle; which, following the long hollow ſide of the lower jaw, of a granular fabric, is ſpread under the membrane of the mouth, by the name of *ſublingualis.* From the larger maxillary, together with this appendix, a duct paſſes out, which, being a long way covered in its middle part by the ſublingualis, receives one, two, or three branches; by whoſe inſertion being increaſed, it opens into a projecting membranous cylinder under the bridle of the tongue. But other ſmall and ſhort ducts from the ſublingual gland, from the number of three, four, or more, to twenty, with ſhort little ducts and points in the line continued backwards from the ſmall frenum, perforate the edge of the tongue, and ſecrete ſaliva. There are ſome inſtances where the larger anterior branch of the duct of the appendix, which uſually joins itſelf to the maxillary gland, goes on ſingle, parallel, and opens by itſelf. Other glands alſo, ſimilar to thoſe of the cheeks, which likewiſe may be reckoned among the ſublingual-ones, by their proper ducts perforate the membrane of the mouth where it departs from the tongue. Various other ſalival ducts have been publiſhed by different profeſſors, which are not confirmed by anatomy.

DCV. The Creator has wiſely provided, that, by the motion of the jaw in maſtication, the ſalival glands ſhall be compreſſed by perfect neceſſity, ſo as to diſcharge their juices into the mouth in greater plenty. For, when the mouth is opened, the maxillary gland, being preſſed by the digaſtric and mylo-hyoideus, throws forth a fountain of ſaliva; the maſſeter when ſwelled preſſes the parotid gland, as does alſo the cutaneous muſcle of the neck which lies over it: and it is this muſcular preſſure that excites the appetite, and pours the ſaliva into the mouth.

DCVI. The food therefore, being in this manner ground betwixt the teeth, and intermixed with the watery ſaliva and air, is broken down into a ſoft juicy pulp, pliable into any figure, and replete with elaſtic air, which by the action of the latter undergoes a farther diſſolution, by the warmth of the parts exciting the elaſticity of the air to expand and burſt aſunder the confining particles of the food, betwixt which it is included. In this act of maſtication, the oily, aqueous and ſaline parts of the food are intermixed the one with the other; the ſmell and taſte of different ingredients are loſt in one, which by the dilution of the ſaline parts with ſaliva renders the food ſlavourable: but ſuch particles as are more volatile and penetrating, being directly abſorbed by the bibulous veſſels of the tongue and cheeks, enter ſtraight into the blood-veſſels and nerves, ſo as to cauſe an immediate recruit of the faculties.

DCVII. But the motions which are neceſſary for turning

ing round the food, applying it to the teeth, and conveying it through the different parts of the mouth in maſtication, are adminiſtered by the tongue, cheeks, and lips. And firſt, the tongue being expanded ſo as to form a ſmall concavity in in its back or ſurface, takes up the food thus prepared, and conveys the charge by its moving powers (CCCCL.) to the parts for which it is deſigned. At one time the tongue, rendered narrow by lateral contraction, ſearches every part of the mouth with its tip, and turns out the latent food into a heap on its common concavity. At another time, applying its extremity to the fore-teeth, and raiſing itſelf up ſucceſſively, it draws from the cavity of the mouth the fluids or chewed aliments, and conveys them to the fauces or back part of the mouth behind the teeth.

DCVIII. But theſe motions of the tongue are likewiſe governed by the muſcles and membranes, largely inſerted into the os hyoides, the baſis of which is internally concave; from whence are extended horns laterally and outwards, terminated by more protuberant heads, and completed with little oval cornices; and this bone being drawn down by its reſpective muſcles, depreſſes the tongue at the ſame time, and the lower jaw likewiſe, if the muſcles of that be relaxed. Theſe powers are the *ſternohyoideus*, but ariſing alſo in part from the clavicle, extenuated upwards, and ſtriped with tendinous lines; the *ſternothyroideus*, ariſing as the former, and broader from the upper rib; which muſcle, depreſſing the cartilage to which it is inſerted, is under a neceſſity of pulling down the *os hyoides*, to which it is joined: this is partly intermixed with the hyothyroideus and thyreo-pharyngeus, and every where confuſed with the ſternohyoideus. Next the coracohyoideus, ariſing from the upper and ſhorter ſide of the ſcapula, near its notch, aſcends obliquely, and at the croſſing the jugular vein changes into a tendon; from whence the other belly of the muſcle aſcends direct to its inſertion into the os hyoides, which it depreſſes, being every where confounded with the ſternohyoideus. The *hyothyroideus* is determined by the former muſcles.

DCIX. The other powers which elevate the os hyoides, together with the tongue, are its *ſtylogloſſus* muſcle, ſuſtained by a peculiar ligament of the upper jaw. The *ſtylohyoideus*, a weak muſcle, often ſplit for paſſage of the biventer, and again united into one portion, after adhering to the tendinous expanſion of the biventer, is inſerted, together with its fellow, into the angle of the baſis, and often into the horn of the os hyoides: the ſecond ſtylohyoideus, when it is preſent, reſembles the former, behind which it is placed; ariſing from the tip of the ſtyloide proceſs, it is inſerted into the ſmall oſſa triticea, and anſwers the purpoſe of a ligament to ſuſtain the os hyoides. All theſe muſcles draw the tongue back, but laterally they elevate it. The *mylohyoideus*, ariſing from the whole length of the jaw, running into one with its companion, elevates the tongue, and fixes it in making various motions, or in like manner depreſſes the jaw. The *geniohyoideus*, being a companion of the geniogloſſus, pulls the tongue forward out of the mouth.

DCX. But, moreover, the muſcles of the cheeks variouſly move and preſs the food in the mouth. Others move it from the cavity of the cheeks into the inner cavity of the mouth behind the teeth, as we ſee in the buccinator when the mouth is ſhut. Others open the mouth for receiving the food; ſuch as the double-headed proper elevator of the upper lip, and the elevator which is partly common; to which add, the zygomaticus, upper and lower; the riſorius, triangularis menti, and the depreſſor proper to the angle of the mouth; which ariſing from an excavation on each ſide, near the ſocket of the canine tooth, are inſerted into the orbicularis of the lips. Others, again, cloſe the lips, that the food received may not return out of the mouth; ſuch as the orbicularis of each lip, the proper depreſſor of the upper lip, and the proper elevator of the lower lip, and that which ſerves in common for the elevation of both.

Of theſe, more particular deſcriptions may be had from profeſſed ſyſtems of anatomy.

DCXI. By theſe means the food, ground and mixed with the ſaliva into a ſoft pulp, collected from all parts of the mouth by the tongue into the arched ſpace betwixt the teeth, is afterward, by the expanſion and ſucceſſive preſſure of the tongue, conveyed backward behind the teeth; and, in this action, the tongue is expanded by the ceratogloſſi and genioglоſſi, and rendered a little concave by the ſtylogloſſus. And from thence it is next conveyed into the fauces.

DCXII. For the tongue being raiſed by the ſtylogloſſi, and broadly applied to the palate, firſt by its apex, then alſo inſenſibly by its poſterior extremity, preſſes the food ſucceſſively towards the fauces, which at that time only afford an open paſſage. After this, the thick root and back part of the tongue itſelf, by the forementioned muſcles, and by the ſtylohyoidei and biventers carried backward, preſſes down the epiglottis, which ſtands up behind the tongue, connected therewith by numerous membranes, and perhaps by ſome muſcular fibres. At the ſame time, the muſcles elevating the pharynx all act together; ſuch as the biventer, geniohyoides, geniogloſſus, ſtylohyoideus, ſtylogloſſus, ſtylopharyngeus, and the other elevators, which now draw the larynx upward and forward, that the epiglottis, being brought nearer to the convex root of the tongue, may be better cloſed or depreſſed. Hence it is neceſſary towards deglutition for the jaws to be cloſed, that by this means the biventer may have a firm ſupport; and, together with the muſcles already deſcribed, elevate the os hyoides. Thus the epiglottis, being inverted, ſhuts up and covers the paſſage very exactly, into the larynx, over which it is extended like a bridge for the aliment to paſs over into the fauces.

DCXIII. By the pharynx [153] we underſtand an ample ſhapeleſs cavity, extended from the occipital bone before the great opening of the ſkull downward, along the bodies of the cervical vertebræ, covered above by the middle cuneiform bone, the opening of the nares, and moveable velum of the palate, receiving the tongue and larynx before, and continued into the œſophagus below. Its ſides are formed by the lower jaw, the cheek, the velum of the palate, the pterygoid proceſs, the ſtiliform appendix, the tongue, os hyoides, and larger cartilages of the larynx. It forms one ſoft membranous bag, outwardly ſurrounded on all ſides by muſcular fibres. Internally it is lined with a membrane continuous to the cuticle, like which it is renewable, but more moiſt. Outwardly it is joined to the pharynx with a good deal of cellular ſubſtance, more eſpecially in its poſterior and lateral parts. By this ſtructure it becomes lax and dilatable, ſo as to receive all bodies that are preſſed by the tongue over the larynx.

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[153] It is moſt elegantly painted by Albinus, Courcelles, and Santorinus, on the back part; and by Camper internally.

DCXIV. It is dilated in its action (DCXII.) by the powers ſerving to its elevation; ſuch as the *ſtylopharyngeus*, ſometimes double, from the proceſs of its name; whence deſcending, it is inſerted into the membrane of the larynx, under the os hyoides, and into the cartilaginous edge of the deſcending thyreoideus; after which, it is broadly ſpread through the internal face of the pharynx, together with the following. The *thyreopalatinus*, being ſpread in the form of an arch round the moveable palate, is from thence extended downwards in two columns, on each ſide the pharynx, which form a conſiderable part of that bag, being alſo connected by broad fibres to the thyreoid cartilage. That the *ſalpingopharyngeus* is a true or diſtinct muſcle, I am ready to believe, rather from the obſervations of eminent anatomiſts, than any of my own. As to the *cephalopharyngeus*, I almoſt deſpair of finding any, unleſs you will reckon the ſtrong white plate of the cellular ſubſtance, which ſurrounds the upper part of the pharynx for a muſcle. This bag cloſely ſurrounds and follows the drink, on each ſide the epiglottis, above the larynx, that it may from thence fall into the œſophagus.

DCXV. That the aliments might not regurgitate into the noſtrils at the time when they are preſſed into the dilated pharynx (DCXIV.), a moveable velum or palate is interpoſed: namely, from the bony palate anteriorly, and laterally from the pterygoide wings, is continued a moveable velum, compounded of the membranes from the mouth and nares, betwixt which membranes are ſpread muſcles and glandules; being almoſt of a ſquare figure, and pendulous betwixt the cavity of the nares and fauces, in ſuch a manner, that they naturally leave the former open, and form a concave arch towards the mouth: and from the middle of this is extended a ſmall portion, pendulous, and of a conical ſhape, before the epiglottis, replete with many ſmall glands; which, from its appearance in a diſeaſed ſtate, is called *uvula*. The elevator of this velum, which is ſtrong, ariſes from the aſperities and plane face of the os petroſum, behind the ſpinal foramen; and from a cartilage of the tube deſcending inward, does, with its companion, form an arch, which is moveable with the palate itſelf, between the two plates of the thyreopalatinus muſcle, ſo as to be brought into a cloſe contact with the ſides of the nares and with the tubes, that none of the aliment may enter into either of them. But this elevator does not ſeem to have any conſiderable action in ſwallowing. At this time regurgitation into the noſtrils is prevented by a conſtriction of the muſcles of the pharynx, together with a depreſſure of the thyreopalatinus, which then manifeſtly draws the moveable velum downward and towards the tongue and pharynx. Add to theſe, the *circumflexus palati mollis*, which ariſes a little more forward from the ſame cuneiform bone, from the internal ſide of its wings, and from the inner wing, with the cartilaginous end of the tube, broad; and then, paſſing through a notch of the pterygoide hook, changes its direction, and aſcends with a radiated tendon through the upper membrane that covers the velum of the palate,

late, joins with its fellow, ſpreads over the other muſcles, and adheres to the edge of the palate bone. This is able both to open the tube, and to preſs down the moveable velum of the palate. Thus the pharynx being contracted like a ſphincter, drives down the food, without permitting any part to return back into the cavity of the nares. Hence, when the velum of the palate is vitiated, the aliments regurgitate into the noſtrils, and a deafneſs enſues.

DCXVI. During this endeavour to depreſs the food by the pharynx (DCXVII.), the velum, drawn back and expanded, is pulled down towards the tongue, by the action of the palatopharyngei, and by the circumflex muſcles of the ſoft palate. Theſe muſcles, together with the gloſſopalatinus, (which laſt is indeed weak, being received into the leſſer arch of the fauces, and here united with its companion into the arch by the velum of the palate, and from thence ſent to the tongue,) preſs the velum againſt the protuberant root of the tongue, and intercept any return to the mouth and noſtrils. After there is no further danger of any part falling into the windpipe, the epiglottis is raiſed up again, as well by its own elaſticity, as by the elevation of the tongue itſelf, by which it is drawn forward. Laſtly, the depreſſed uvula is raiſed by the azygos, which ariſes from the tendons of the circumflexi muſcles and levator of the ſoft palate.

DCXVII. A little after this follows an attempt to urge the food downward, which is exerted by the conſtrictor muſcles of the pharynx which draw the fore parts towards the back, and the muſcles which are partly tranſverſe and partly aſcend into the poſterior ſurface of the pharynx. Of theſe the principal is the pterygopharyngeus, ariſing from the whole hook and internal edge of the wing, and from the tendon of the circumflex muſcle; from whence forming an arch, it is extended upward and backward, and, largely ſurrounding the upper part of the pharynx, it joins into one with its companion, which has the ſame name. The mylopharyngeus, partly continuous with the fibres of the buccinator, in the middle betwixt its two adheſions to the bones, ariſes alſo in part from an origin of its own, above the laſt of the grinding teeth in the lower jaw. Theſe having a courſe almoſt tranſverſe, ſurrounding the pharynx, draw it back towards the fore part. Next to theſe follow the geniopharyngei, aſcending in two ſtrata of obſcure and confuſed fibres which originate from the tongue; next the chondropharyngei, of a triangular figure, ariſing from the oſſicula triticea; the ceratopharyngei, which aſcend radiated from half of the horn; the ſyndeſmopharyngei, ariſing from the horn of the thyreoide cartilage, and diſtinct from the former; to which add, the thyropharyngei of both kinds, increaſed by the fibres of the ſternothyroideus and cricothyroideus, with the cricopharyngei, the tranſverſe, the aſcending, and the deſcending. Theſe muſcles acting ſucceſſively from above downward, according to their ſituation, drive the aliment into the œſophagus. At the ſame time the depreſſing muſcles of the larynx, coracohyoideus, ſternohyoideus, and ſternothyreoideus, draw down the larynx forward, and leſſening the capacity of the pharynx urge the food downward. But in this action, as the aliment paſſes by the poſterior rima of the glottis, the arytænoidei contract the larynx perpendicularly.

DCXVIII. As various dry and rough bodies are frequently ſwallowed, it was neceſſary for the pharynx to be dilatable and not very ſenſible of pain; to which end the great quantity of mucus, which is collected in all parts of the fauces greatly conduces. Therefore, in general, betwixt the nervous and innermoſt coat of the pharynx, are placed a great number of ſimple mucous follicles or cells, of an oval figure, pouring out their mucus through ſhort mouths; of a ſoft, viſcid, and ſomewhat watery nature; but ropy, or drawing out into threads, not without oil, and abounding more with volatile ſalt and earth than the ſaliva itſelf. Theſe mucous receptacles are moſt plentiful in that part of the pharynx which is immediately extended under the occipital bone, where they are diſpoſed in a ſort of radiated right lines; and they are likewiſe numerous about the tonſil, toward its tube, where commonly the ſecond tonſil on each ſide lies adjacent to the large one, and in that portion of the pharynx which is called ſalpingopharyngeus. But there are likewiſe other flat and circular follicles, ſeated in great numbers about the back part of the tongue, as far as its foramen cæcum (CCCCXLVIII.) Other follicles and pores of the ſame kind are every where ſeated in the pulpy fleſh of the palate, where numerous ſmall glands diſcharge ſuch a viſcid mucus. Moreover, the whole ſurface of the moveable palate is of a glandular nature like that of the pharynx; only the follicles and glandular corpuſcles are here more numerous and thickly ſet together. Nor, laſtly, are lacunæ wanting, into each of which are joined many ſimple glandules.

DCXIX. Where the pharynx deſcends laterally from the little pterygoidal hook betwixt the two arches of the fauces, namely, between the gloſſopalatinus and pharingopalatinus, are ſeated the tonſils, of an oval figure, convex behind, and thick on the upper part, perforated inward with ten or more large ſinuſes, which open through the membranous covering of the velum extended over them, and by the preſſure of the adjacent muſcles diſcharge a great quantity of a moſt thick mucus from their ſinuſes. In like manner, the adjacent parts of the nares, and projecting ring of the tubes, and that ſide of the epiglottis which lies next to the larynx and the back of the arytænoide cartilages, are alſo repleniſhed with mucous organs. Laſtly, the œſophagus itſelf, on all ſides, abounds with ſimple follicles, from whence a mucus is poured out ſomewhat more fluid. But the larger glandulæ œſophagææ are of the conglobate kind, and conduce nothing to this mucus. The blood-veſſels of the tonſils are ſupplied from thoſe of the tongue, lips, and pharynx itſelf; as thoſe of the œſophagus are derived from the branches of the pharynx, upper and lower thyreoidals, from the bronchials and aorta. The veins of the palate and tonſils being numerous, run together into a net-work, ending in the ſuperficial branch of the internal jugular.

DCXIX. The *œſophagus*, then, is a double tube, of which the innermoſt is ſeparated from the outer by a good deal of cellular ſubſtance, that may be inflated. The innermoſt tube of the œſophagus is nervous and ſtrong, being continued from the membranes of the mouth and nares, on its inner ſide plaited and porous, having an epidermis which is not villous, but pulpy, and exhaling a thin humour; it is diſtinguiſhed by a thin cellular ſubſtance, in which the ſmall veſſels are reticulated with minute glands interſperſed, which are continuous, and ſimilar to thoſe of the pharynx. The outer tube is muſcular, and in itſelf conſiderably ſtrong, compoſed of fibres internally continued from the lower and back part of the cricoide cartilage, which, by degrees, change from annular to fibres that are externally longitudinal, and ſerve to draw up and dilate the œſophagus againſt the food, that the mouthful may be received. But the other internal circular fibres, which are ſtronger than the former, ariſe in like manner from the top of the cricoide cartilage; and by their ſucceſſive contraction againſt the food, drive it down through the whole long tube of the œſophagus, which deſcends firſt in a direct courſe, a little to the left ſide of the windpipe; but having reached the cavity of the breaſt, it paſſes behind the heart, through the cellular interval that lies behind the bag of each pleura (LXXVII.); from whence, inclining by degrees a little to the right, it afterwards bends again forwards to its proper opening, by which its included food paſſes through the diaphragm (CCLXII.) in the interval of time that is betwixt exſpiration and inſpiration. Outwardly, the whole tube of the œſophagus is ſurrounded by the cellular ſubſtance, by which it is looſely tied to the neighbouring parts.

DCXX. The aliments are moved through the œſophagus as through an inteſtine. The longitudinal fibres, aſcending to the cartilages of the larynx, dilate the gullet, oppoſite to the deſcending morſel. But when it is received, the longitudinal fibres equally dilate and elevate the gullet at that place which receives it. Then that part of the œſophagus where the morſel is ſeated, being irritated, contracts, and moves the food downwards. The muſcle is ſtrong, and very irritable.

DCXXI. This upper opening of the ſtomach is contracted or compreſſed in ſuch a manner, by the lower muſcle of the diaphragm, in every inſpiration, as to confine the food within the ſtomach, and direct it in every exſpiration, by preſſure, naturally towards the pylorus. By this means, the ſtomach is ſo cloſely ſhut, that in the moſt healthy man even wind or vapours are confined within the ſtomach; nor do they ever aſcend but by a morbid affection.

CHAP. XX.

Of the Action *of the* Stomach *on the* Food.

DCXXII. BY the *ſtomach* we underſtand a membranous bag, deſtined for the reception of the food; placed within the cavity of the abdomen, behind the liver and left falſe ribs; in general of an oval figure or like a caſk; of a larger diameter tranſverſely, and this more ſo as the perſon is more adult; but in the fœtus it is altogether ſhort and round. But if we conſider more accurately every ſection of its figure, they will appear circular; although there be a blind or obtuſe concavity in its left extremity, from whence it grows wider towards the œſophagus, at whoſe inſertion its light or ſection is the largeſt of all; from thence it diminiſhes by degrees, till bending in a contrary direction to itſelf, it ends in the pylorus. Its bulk depends on the quantity of food, by which the cavity of the ſtomach is augmented; and, on the contrary, it is diminiſhed by famine. Its ſituation in general is tranſverſe; yet ſo that the œſophagus enters its poſterior ſide, and the pylorus goes out from it forward to the right ſide. The middle of the human body, or enſiform cartilage, thus covers or anſwers nearly to the centre of the ſtomach; but alſo to the right ſide, and laſtly to the pylorus; to the latter anſwers the umbilical fiſſure. Since its figure is round but incurvated, its lower convexity will form a larger pendulous arch when empty; but when full, it ſhows itſelf prominent before, and in contact with the peritonæum. On the other hand, the leſſer arch, intercepted betwixt the two orifices, will in this ſtate of the ſtomach lie perfectly backward towards the ſpine, ſo as to include the ſmall lobe of the liver. Thus the inſertion of the œſophagus into the full ſtomach will be in an obtuſe angle, in a manner parallel with the horizon; but in the empty ſtomach it will be almoſt perpendicular: and at the ſame time, the right extremity of the ſtomach forming the pylorus, which in an empty ſtate lies bent upward, will in the full ſtomach be bent more backward, ſo as to deſcend in perſons lying on their back. In a living man, that ſituation of the ſtomach which we have attributed to the full one is neareſt the truth.

DCXXIII. In the neighbourhood of the ſtomach lie the viſcera: and particularly to its large imperforated extremity is connected the ſpleen, by a conſiderable portion of the omentum; the leſſer arch or curvature of the ſtomach receiving the little lobe of Spigelius, as likewiſe the left lobe of the liver largely interpoſing betwixt the ſtomach and the diaphragm; which lobe compreſſes the forepart of the ſtomach; below the margin of which, a portion of the ſtomach lies immediately contiguous to the diaphragm itſelf; yet ſo as, by a moderate extenſion, to lie hid within the bounds of the falſe ribs. Under and behind the ſtomach, lies the pancreas, extended for a conſiderable length in an empty ſpace, upon the tranſverſe portion of the colon. Again, from the leſſer curvature ariſes the little omentum, to which is continued the ſtronger membrane that connects the œſophagus with the diaphragm: nor is the large omentum connected to the whole length of the ſtomach; but, leaving a deficiency to the right ſide near the pylorus, it is continued on beyond the left extremity, into a ligament which connects the ſtomach and ſpleen together. The ligaments, in theſe parts, are productions of the peritonæum; which, receding from the diaphragm, ſpreads itſelf over the ſtomach ſo as to form its outermoſt coat. The pylorus lies between its mouths, on the forepart, more to the right ſide, and a little lower down.

DCXXIV. The fabric of the ſtomach anſwers in general to that of the œſophagus; of which, indeed, it is an expanſion; and, in ſome animals, has in all its parts the ſame appearance. The outermoſt coat is from the peritonæum, of conſiderable ſtrength, ſo as to limit the reſt, and afford a ſupport to the ſubjacent muſcular fibres: this is expanded into the little and great omentum, and in that place the ſtomach is without its outermoſt coat. Then follows the cellular coat more abundant in the origin of the little omentum, where it contains little conglobate lymphatic glandules, which alſo holds true of the cellular ſubſtance in the great omentum; but it is thinner and much leſs conſiderable betwixt the coats of the ſtomach iſelf, whence the outer and muſcular tunic cloſely cohere together: in this ſubſtance the larger branches of the veſſels are diſtributed.

DCXXV. Next in order appears the muſcular coat, neither eaſy to deſcribe or prepare. Here, indeed, we ſee the longitudinal fibres of the œſophagus, coming to the ſtomach, are detached one from another, along all the ſides of the ſtomach. Some of them, of more conſiderable ſtrength, run on to the pylorus, along the leſſer curvature; which, by degrees declining from their longitudinal courſe, following the length of the ſtomach, deſcend into a plain of each ſide, and are in part ſtretched out through the pylorus into the duodenum itſelf, where they gradually diſappear. Other fibres deſcend to the blind ſac of the ſtomach, ſeated on the left ſide.

And, finally, through every ſection of the ſtomach, from its blind or left extremity, to the pylorus, are ſpread concentric circular fibres, which, by degrees increaſing in their thickneſs or number, are continued on with the reſt of the circular fibres belonging to the ſtomach: this laſt makes the moſt conſiderable order of the muſcular fibres. Laſtly, the ſphincter of the cardia and œſophagus is compoſed internally of fibres, ariſing from the left ſide of the œſophagus, and running to the right, paſs on each ſide the gula, which they thus cloſely embrace, and then degenerate longitudinally till they are loſt under the circular or ſecond ſtratum near the pylorus. But the ligaments of the pylorus ſo called, are two conſtrictions, betwixt the two incurvations into which the pylorus is bent, formed by the foreſaid longitudinal fibres, which run along from the ſtomach to the pylorus, and are very cloſely joined to the internal coat in their way.

DCXXVI. Immediately under the muſcular fibres, follows another cellular ſtratum, larger than the outermoſt, ſofter, more eaſily inflatable, and conſiſting of larger cells or veſicles than what we uſually obſerve in the inteſtines. Within this cellular ſubſtance are ſpread the veſſels which, coming from the larger trunks, perforate the muſcular coat, and are divided into an angular network. Under this lies the nervous coat, which is thick, white, and firm, and properly makes up the true nature or ſubſtance of the ſtomach itſelf, after the manner of other nervous parts: and this is again lined internally with a third cellular ſtratum, evidently enough to be perceived, whoſe vaſcular net-work is much more minute than that of the former, from whence it is derived. Immediately within this lies the villous coat that lines the cavity of the ſtomach itſelf, continuous with the external cuticle, like which it is renewable; but of a ſoft mucous texture, and extended into a very ſhort pile, and folded into large plates, which form a ſtar under the œſophagus; but in the middle of the ſtomach, theſe folds are almoſt parallel with the ſtomach itſelf.

But, at the extremity of the pylorus, there is a more conſiderable fold, commonly called valvula pylori, which is formed by a production both of the tranſverſe muſcular fibres, and of the thicker nervous coat, extended together in the ſhape of an unequal looſe ring, produced towards the duodenum; this forms a ſlippery fleſhy protuberance, which ſurrounds the duodenum for a conſiderable length. The large wrinkles of the villous membrane are afterwards ſubdivided more minutely into others of a quadrangular or net-like figure; but very ſhallow and eaſily diſappearing, being much more obſcure than thoſe in the biliary ducts. Within this villous coat of the ſtomach throughout, but more eſpecially towards the pylorus, I have truly obſerved ſome pores, not always to be perceived, which terminate in ſimple follicles, ſeated in the next cellular ſtratum.

DCXXVII. The *veſſels* of the ſtomach are both numerous and derived from many trunks or various quarters, that the courſe of the blood through them might not be intercepted by any kind of preſſure, as might eaſily have been if the veſſels of the ſtomach had come from a ſingle trunk. The common mother of all theſe gaſtric arteries is the cœliac; from the threefold diviſion of which, or above the ſaid diviſion, ariſes the upper coronary, which is the firſt and largeſt artery that paſſes in a ſingle branch round the edge of the œſophagus into the ſtomach; to which, firſt, and afterwards to the diaphragm and to the liver, it ſends off ſome ramifications; and then running on the leſſer arch or curve of the ſtomach, it inoſculates by more than one branch with the leſſer coronary of the right ſide, ariſing from the right branch of the cœliac at the vena portarum, and is diſtributed along the leſſer curve of the ſtomach. But the ſame right branch of the cœliac, ariſing behind the duodenum, along which it deſcends, gives off a very conſiderable artery that runs contrary to the great arch or curve of the ſtomach, the *right gaſtro-epiploica*, which being ſuſpended in the omentum, it ſpreads itſelf both upon each ſide of the ſtomach, and upon the greater part of the omentum itſelf, being at laſt inſerted into the *left gaſtrico-epiploica.* Namely the left trunk of the cœliac, paſſing along in the direction of the pancreas and ſinuoſity of the ſpleen, there ſends off many branches to the ſtomach: of which the firſt are commonly nameleſs; and among the following, one branch, more conſiderable than the reſt, is called the *left gaſtro-epiploica,* which ſends off a conſiderable twig to the omentum, with ſome others that are ſmaller: from whence, deſcending round the ſtomach towards the right ſide, it inoſculates with the right artery, which is its companion. Other ſmaller ones, coming from thoſe of the ſpleen, are ſpread upon the greater curve of the ſtomach, even as far as the diaphragm, under the denomination of the *vaſa brevia.* Frequently, alſo, one or two arteries come from the ſplenic one, to the poſterior plate of the ſtomach under the œſophagus, in another line from the gaſtro-epiploics. The other ſmaller arteries are the upper ones of the pylorus from the hepatics, and the lower ones from the gaſtro-epiploics: but thoſe of the lower part of the œſophagus are from the phrenic arteries.

DCXXVIII. Thoſe arteries are diſtributed in ſuch a manner, that firſt they ſend off ſhort twigs to the external and to the muſcular membranes of the ſtomach; their trunks are ſet in order in the firſt cellular ſtratum; from whence, diminiſhing a little in ſize, they penetrate through the muſcular coat; and between that and the nervous membrane, they compoſe a larger and true net-work; in which all the ſmall arteries, coming from a great variety of trunks, join one with another, by an infinity of inoſculations. From this plexus, again, other ſhort, but numerous and very ſmall ramifications, paſs through the nervous coat to the third or inner cellular ſtratum, and are loſt in the villous lining of the ſtomach.

DCXXIX. The *veins* have their branches diſtributed in company with the correſponding arteries. The greater coronary from the left ſide of the ſtomach, generally goes to the trunk of the porta, together with the brevia and left gaſtro-epiploic; while the right vein of the laſt denomination joins with the middle vena colica, and, together with a branch from the meſentery, pours its contents into the vena portarum. Finally, the right coronary vein belongs to the trunk of the vena portarum itſelf. All theſe veins are without valves; and, like the arteries, there are upper coronary veins, with others of the œſophagus from the thorax, all communicating together by inoſculations, in ſuch a manner, that there is a free paſſage for the blood thence into the vena azygos, with which they inoſculate.

DCXXX. The *nerves* of the ſtomach are both large and numerous, produced from the eighth pair, forming two complications about the œſophagus, of which the anterior and leſs plexus deſcends through the upper or outer ſide of the ſtomach to its greater curve; and the poſterior plexus, which is larger, is diſtributed through the leſſer arch of the ſtomach; from whence it paſſes, together with the arteries, to the liver, pancreas, and diaphragm itſelf. Theſe nerves may be every where traced into the ſecond cellular ſtratum. The remainder, but eſpecially the papillæ, are more obſcure. From their number, the ſtomach is extremely ſenſible, inſomuch, that things which make no impreſſion upon the tongue, will nauſeate and pervert this organ, which is capable of much ſeverer pain than the inteſtines; as we know from infallible experience in diſeaſes: even the ſkin itſelf, when naked by a bliſter, is leſs ſenſible than the ſtomach. By making a ligature upon the nerves of the eighth pair, both the action of the ſtomach and the digeſtion of the food ceaſe.

DCXXXI. *Lymphatic veſſels* I have obſerved, ſometimes very conſiderable, about the leſſer curve of the ſtomach, ariſing from the glandules of that part, and inſerted by a very large trunk into the thoracic duct. Others, no doubt, ariſe from ſmall glandules of the ſame kind in the greater curve; and ſome famous anatomiſts have obſerved lymphatic glands over the whole ſtomach.

Other lacteal veſſels, I have neither ſeen, nor am ready to admit; ſuch as thoſe lately deſcribed, which are ſaid to paſs from the ſtomach through the omentum to the liver, filled with a true chyle.

DCXXXII. All parts of the human ſtomach are perforated by inorganic pores, through which water injected both exhales through the ſtomach when ſhut, and, on the contrary, penetrates the cavity of the ſtomach when put under water. But we cannot for this reaſon conclude, that in a living perſon this paſſage lies open for moiſture.

DCXXXIII. Within the human ſtomach, we firſt meet with a great quantity of *mucus*, ſpread upon its villous lining, from the pores before deſcribed (DCXXVI.); which mucus is not unfrequently tinged, by ſome of the bile returning into the ſtomach. Beſides this, in an empty ſtomach after faſting, upon bending the body, a great quantity of a *limpid humour* will ariſe into the mouth, altogether of the ſame nature with the ſaliva, but more mucous; which liquor is very rarely to be found pure or unmixed in the ſtomach. It is very far from poſſeſſing any acid acrimony, when it can be had pure from the food. Left to itſelf, it changes, both in man and brutes, rather to a lixivial or alkaline nature, when it is ſeparated from the acid illuvies of the aliments, more eſpecially in an hungry animal. This liquor diſtils from the arteries of the ſtomach, through its villous coat, after the manner we ſee by anatomical injections: by which, water, fiſh-glue, and oil, may be eaſily urged into the veſſels of the ſtomach, ſo as to ſweat through its numberleſs pores.

DCXXXIV. The ſtomach then, contained within the abdomen, which is perfectly full, will from thence, as in a preſs, receive a force or compreſſure upon its ſides, which lie betwixt the diaphragm; the concavity of whoſe right wing is filled by the liver, under which, and within the left wing, lies the ſtomach, extended almoſt tranſverſely behind the reſiſting muſcles of the abdomen, viz. the recti and obliqui; but chiefly the tranſverſe. The more the ſtomach is filled, the more it is urged by this preſſure of the abdominal muſcles; becauſe, at the ſame time, it riſes upward in a right angle to the contact of the peritonæum.

DCXXXV. Now we muſt ſpeak of what is received into the ſtomach, and why it is received. The Creator has given to man the two faithful guards of pleaſure and pain (DLXIV.) for his preſervation; the one to avert evil, the other to invite him to uſeful actions. But the taking of aliment is an action very neceſſary and uſeful to our ſupport. For ſince every day there is a great quantity waſted from the body, by a diſſolution of its true ſubſtance thrown off by perſpiration, a repairing of this loſs is every way neceſſary, as the body is manifeſtly waſted by faſting. But this neceſſity of taking food recurs the more quickly from the nature of the blood itſelf, which is ſtrongly inclined to a ſharp, ſaline, lixivial quality, and to a putrid acrimonious ſtate; to which laſt it is continually ſolicited, and approaches, from the putreſcent diſpoſition of all the more ſtagnant humours of the animal, promoted by the inceſſant and natural motion of the heart and arteries, and by the heat which very much promotes the putrefaction of all the animal humours. Moreover, the coagulable diſpoſition of the blood, continually loſing a great part of its diluting water by inſenſible perſpiration, calls ſtrenuouſly for a recruit of the watery element, in the way of drink, by which its coheſive globules are ſeparated from each other, and hindered from running together into a conſiſtent maſs.

DCXXXVI. Theſe truths are proved not only from their cauſes, but likewiſe by the appearances which they exhibit in men and other animals killed by hunger. For, in ſuch, we commonly obſerve a ſharp ſtinking breath, a looſeneſs of the teeth from the diſſolving acrimony of the juices, violent pains in the ſtomach, ſharp fevers, and even a true madneſs. All theſe diſorders ariſe ſooner and ſtronger, as the perſon is more robuſt and more violently exerciſed with motion of body; but they enſue very ſlowly in phlegmatic people, who are unactive, perſpire little, and put the blood into no great motion. Laſtly, thoſe who have been without food, have alſo lived without bodily exerciſe, and for the moſt part laboured under a diſeaſe of the nerves.

DCXXXVII. The freſh chyle, compoſed, for the moſt part, out of the aceſcent claſs of vegetables, and of a conſiſtence always thinner than that of the blood itſelf, being received into its torrent of circulation, temperates the putreſcent acrimony, dilutes the coagulation threatened, and reduces the whole maſs to that moderate degree of ſaline narure which is natural to man: and finally, the chyle, but more eſpecially that derived from the fleſh of animals, and likewiſe what is formed of farinaceous vegetables, being repleniſhed with gelatinous lymph, ſerves to repair the conſumption or waſte which is made from the body itſelf, to the vacuities of whoſe broken ſolids it is applied by the cauſes mentioned (DCCCCLIX.) The drink dilutes the coheſive or grumous inclination of the blood, hinders its putrefaction, and carries off by the emunctories ſuch particles as are already putrid: and hence it is, that a perſon may live for a long time without ſolid food, if he is ſupplied with drink; but without drink, life ſubſiſts but a few days.

DCXXXVIII. We are ſolicited to take food, as well from the ſenſe of pain we call hunger, as from that of pleaſure, which is received by the taſte (CCCCLV.) The firſt of theſe proceeds doubtleſs from the ſenſible folds or wrinkles of the ſtomach rubbing againſt each other by the periſtaltic motion, of which there is an acute ſenſation, joined with a preſſure from the diaphragm and abdominal muſcles, by which the naked villi of the nerves on one ſide grate againſt thoſe of the other, after a manner intolerable. Thus we are effectually admoniſhed of the dangers enſuing from too long abſtinence or faſting, and excited to procure food or nouriſhment by labour and induſtry. To this ſenſe perhaps the gaſtric liquor or juice of the ſtomach, collected and ſharpened after feeding, does in ſome meaſure conduce, unleſs it becomes putreſcent,

DCXXXIX. *Thirſt* is ſeated in the tongue, fauces, œſophagus, and ſtomach. For whenever theſe very ſenſible parts, which are conſtantly and naturally moiſtened by mucous and ſalival juices, grow dry from a deficiency of thoſe or the like humours, or are irritated by a redundancy of muriatic or alkaleſcent ſalts here lodged, there ariſes a ſenſe much more intolerable than the former, as thirſt is more dangerous; whoſe uneaſy ſenſe continues until the proportion of diluting water in the blood, being recruited, reſtores the neceſſary moiſture and free ſecretion required in the parts before mentioned. From hence we learn, why thirſt attends labour, which exhales a greater proportion of the watery perſpiration; and why it is a ſymptom of fevers, where there is an obſtruction of the exhaling veſſels belonging to the tongue and fauces; why ſimple water is leſs efficacious in abating thirſt, which yields nevertheleſs eaſily to ſome acid liquors, that not only moiſten and render fluid, but alſo, by their mild irritation of the tongue and mouth, provoke forward the humours, and at the ſame time correct their putrid tendency.

DCXL. From theſe cauſes, mortals, being under a neceſſity of ſeeking food for the ſupport of life, have in all ages determined their choice to the ſucculent parts of vegetables, and animals, in ſuch a manner, that water and ſalt ſeem to be added only as third aſſiſtants. And firſt, it is probable, that the primitive choice of our foods was made by experiments, according as the variety of ſmells and flavours in vegetables and their ſeveral parts invited, and as the ſtrength or recruit of our faculties thence following confirmed their utility. But by degrees, animals increaſing ſo much as to be incommodious to the huſbandman, and vegetables alone not being ſufficient for ſupporting them under their labours, the fleſh of animals was afterwards added. At preſent, both the number and variety of ſubſtances are almoſt infinite, which we take either as food or ſeaſoning for our nouriſhment.

DCXLI. Although there are many inſtances of particular perſons, and even of whole nations, who have ſupported life only with one kind of food, either vegetable or animal, or even from a ſmall claſs of either of them; and laſtly, though ſome have lived altogether upon milk or its whey; yet it ſeems to be neceſſary, both from the nature and fabric of the human body itſelf, as well as from certain experiments, that we ought to ſupport life by the two kinds of food, ſo intermixed, that neither of them may exceed their reaſonable bounds; and this mediocrity we are taught from the loathing itſelf, which follows to any one kind of food that has been continued for too long a time together.

DCXLII. The fleſh of animals appears a neceſſary part of our nouriſhment, even from the fabric of the human ſtomach itſelf, reſembling that of carnivorous animals; and from the two rows of teeth, with the canine teeth in each jaw; alſo from the ſmallneſs and ſhortneſs of the inteſtinum cæcum, and from the neceſſary vigour which we require. For the fleſh of animals alone contain the gelatinous lymph ready prepared for the recruit both of our fluids and ſolids, which, being extracted from the broken veſſels and fibres, eaſily paſſes in great abundance into the blood. An abſtinence from animal food generally cauſes great weakneſs both to the body and ſtomach, being perpetually attended with a troubleſome diarrhœa But in the amplitude and length of the inteſtina craſſa, man agrees with herbivorous animals.

DCXLIII. Eſculent vegetables are generally of the aceſcent kind; only ſome few of them are either alkaleſcent, or elſe repleniſhed with a ſpicyneſs. But few of them have that animal glue which is ſpontaneouſly changeable into blood; for it is only the ſmall portion of jelly which is drawn from their farinaceous parts, that, after many repeated circulations, is converted into the nature of our indigenous juices. Yet theſe are neceſſary to avoid over repletion with blood, and of too putreſcent a kind from the uſe of animal food alone, which, from the moſt creditable accounts of the anthropophagi, prevails to ſo great a degree as to breed the hot alkaleſcent ſcurvy, a fierce or ſavage temper, a ſtinking and leproſy of the body, with a lixivial corruption of all the juices; which are only to be cured by change of diet, in which a vegetable acidity abounds. Hence it is, that we are furniſhed but with few canine teeth; and that our appetite in health, but more eſpecially in diſeaſe, is ſtronger for acidulous vegetables, in proportion to our warmer temperature of body, and greater heat of the country or the ſeaſon of the year. Hence we ſee, that in the hotteſt climates, people live either altogether upon vegetables, or uſe fleſh meats but very rarely, and not without danger of acute diſeaſes; while, in the colder countries, fleſh is eaten freely with leſs danger: and hence bread, or a farinaceous aliment ſimilar to it, is made a ſtanding part of our food throughout the world.

DCXLIV. The beſt *drink* is afforded by pure water, not incorporated with ſalts, nor with air, which may excite fermentations. Of this kind we juſtly prefer that from a mountainous ſpring, which runs through a ſandy bed, being very cold, clear, light, and inſipid. Whenever we are unprovided with ſuch pure water, as is frequently the caſe in the lower flat countries, or when any increaſe of the ſtrength and muſcular conſtriction of the ſtomach is required from a ſpicy ſtimulus, its place may be very well ſupplied by wine, prepared chiefly from grapes; but, in defect of thoſe, from apples and pears; which, after a due fermentation, becomes clear, and is repleniſhed with an acid ſalt, and oily or inflammable ſpirit, well diluted in water. Liquors of the ſame kind, repleniſhed with a vinous or inflammable ſpirit, but more flatulent, heavy, and leſs palatable, are prepared from corns roaſted, afterwards extracted with boiling water, and prepared by fermentation,

tion, as a ſubſtitute for wine in thoſe countries where the grape does not ripen.

DCXLV. But mankind have invented various pickles and ſauces, ſuch as ſalt, vinegar, and acids of various kinds, to correct the putreſcent diſpoſition of fleſh-meats; with pepper, muſtard, and other hot ſpices, to ſtrengthen the action of the ſtomach, which is perpetually weakened by the uſe of vegetables: and to theſe add, ſugar, ſalt, and the eaſtern ſpices, which are generally added either for the ſake of flavouring or preſerving our food. But all theſe yield no nouriſhment, being deſtitute of all gelatinous lymph, or any farinaceous quality. The ſpirits of wine and corn may be of ſome uſe as medicines, but are unfit for drinking.

DCLXVI. The aliments are variouſly prepared, according to the difference of country, climate, or ſeaſon; and thus their crudity is removed, their ſolid fibres ſoftened, their ſuperfluous air expelled, and their diſagreeable acrimony changed and rendered agreeable. But, even after this, many vegetable foods, and more eſpecially fleſh-meats, require to be divided, in ſome degree, by a previous triture in the mouth, which is particularly neceſſary in man, whoſe ſtomach is but little fleſhy, and likewiſe that the food may not ſtay ſo long upon the ſtomach as to become putrid.

DCXLVII. The meaſure of our food is determined by hunger, which is different according to the difference of bodies. Animal and farinaceous food nouriſhes moſt: other aliments ought to ſupply by their quantity, what they want in their powers of nouriſhment. In general, we are nouriſhed beſt by a ſomewhat ſpare diet, unleſs ſubjected to much labour.

DCXLVIII. Into this ſtomach, therefore, the aliments are let down, often almoſt crude, and but little chewed, of various kinds; ſome of them being alkaleſcent, as fleſh-meats; ranceſcent, as oily or fat ſubſtances; or aceſcent, as bread, milk, and moſt of the vegetable kind. Theſe, we obſerve, are digeſted in a heat equal to that of an hatching egg, adminiſtered to the ſtomach by the contiguous ſpleen, liver, and heart; and this in a cavity altogether cloſe or confined, above (DCXXI), as it alſo is below, by the aſcent of the incurvated pylorus, and in a great meaſure by a ſhutting valve, and likewiſe conſtringed by a muſcular force of the fibres; from whence we obſerve, that even milk itſelf is often retained in the ſtomach of ſtrong animals ſeveral hours after a meal, without paſſing into the inteſtines. Obſerve, again, that theſe aliments are continually cohobated or moiſtened with watery juices and at the ſame time are repleniſhed with a good deal of air incorporated with them, either naturally or in the maſtication. This air, therefore, expanding by the force of heat, putrefaction, or fermentation, breaks open the cells by which it was included, divides the viſcid liquors, and ſoftens or opens the ſolid fibres, ſo as to make a way for diſcharging their juices. But the ſame ſubſtance of the air, turning to a ſolid, makes the principal glue or cement by which the animal ſolids and other bodies receive their firmneſs; and this, being extricated by heat, leaves the other elementary parts friable, or without a vinculum, as we ſee from the change which happens in Papin's digeſter, in the ſtomachs of many animals, and even in that of ourſelves. This air, ſet at liberty by the digeſtion, often diſtends the ſtomach more than the food itſelf, under the denomination of flatus. While this air is extricated, the aliments by long ſtay begin to corrupt or change into a nauſeous liquid, often aceſcent; or otherwiſe putreſcent, which however happens leſs in mankind from our uſe of bread and ſalt; or ranceſcent, as appears from the flatus and matters eructated, often of a moſt fetid, cauſtic, and inflammable nature, from ſubſtances of the like diſpoſition. This putreſcency, or imperfect putrefaction, is almoſt the only cauſe of digeſtion in fiſh, ſerpents, and carnivorous birds. Hence, in mankind, metals themſelves, by long ſtay in the ſtomach, grow ſoft, and are eroded. At this time hunger is abſent, the nervous plates of the ſtomach being removed and defended from their contacts with each other by the interpoſed aliment, at the ſame time that the juice of the ſtomach itſelf is leſs ſharp and freer from a mixture with the old remains of the laſt food, which often excite a nauſeating uneaſineſs in the nerves of the ſtomach.

DCXLIX. But that the aliment might not degenerate into a complete acidity, there is a check from the putreſcent degree of the heat, the power of the juices diſtilling from the ſtomach, and that of the ſaliva itſelf, ſwallowed to the amount of half an ounce in an hour, and rather inclined to an alkaleſcency: alſo theſe juices being ground together with the aliment, macerate, ſoften, and diſſolve the fibres themſelves and their cellular bands, leaving them a ſoft pulp like what we ſee by letting them ſtand for a long time in warm water, extract their juice, and mingle it with themſelves. There is therefore no particular kind of ferment in the ſtomach[151]; from which the deſign of nature, the diſpoſition of the ſtomach, and its uſe, are all very remote. And yet the juice of the ſtomach alone, by its longer ſtay in fiſhes, diſſolves the bones which they had devoured.

DCL. For the fleſhy fibres in the ſtomach being now irritated by the flatus, weight, and acrimony of the food, begin to contract themſelves more powerfully than when the ſtomach is empty, and with a greater force in proportion as it is more full, the round ſwelling of which ſtretches theſe fibres. And, firſt, the muſcular ſtratum, which paſſes along the leſſer curvature, connects the pylorus with the œſophagus; and, being inſerted only into the left face of the former, draws it to the right. The principal ſtratum of the circular fibres contracts the capacity of the ſtomach, acccording to its length; grinds or intermixes its contents

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[154] The ſtomach's action upon the food, which is performed in ſome by fermentation alone; in others by putrefaction; in many by trituration; in ſome, in ſhort, by maceration alone; is carried on in none by real alkaleſcence. In man, who is furniſhed with a weak ſtomach, digeſtion goes on by means of ſeveral cauſes co-operating, which are fully deſcribed by M'Bride.

tents together with the liquors (DCXXXIII.); and determines them both, like the preſſure of two hands placed oppoſite, to flow towards the pylorus: but this flux through the pylorus is not made continually, for reaſons before aſſigned (DCXXVI), as well as becauſe this motion begins from ſome part that is more irritated; and from thence the aliment is driven here upward, as in other parts downward. Theſe alternate contractions at laſt terminate in a full evacuation. In this action of the ſtomach, there is nothing which reſembles the triture made by the ſtrong gizzards of granivorous fowls, which ſome anatomiſts have aſcribed to the human ſtomach; which yet has a conſiderable degree of ſtrength, ſince the contraction of its fibres is often more than a third part of their length; for we frequently ſee the ſtomach reduced to leſs than a third of its diameter: frequently alſo the ſtomach is obſerved to be diminiſhed to much leſs than a third part, even to the breadth of an inch; which, laſtly, makes it fit for moving forward ſharp-pointed ſubſtances. Yet it neither bruiſes berries nor the ſofteſt worms.

DCLI. But that motion which it receives from the diaphragm and muſcles of the abdomen, is ſtronger than the periſtaltic force of the ſtomach; for, by this, the ſtomach is more perfectly emptied by a cloſe approximation of its anterior and poſterior ſides. For it is principally by this force that the drinks are urged on continually, but the foods only when they are diſſolved, leſt thoſe parts which are too groſs ſhould be expelled through the pylorus into the duodenum, when the ſtomach is more that way inclined by repletion; for the ſolid aliments do not ſeem to leave the ſtomach, before they have changed their fibrous or other texture for that of a mucous, as it were cineritious, yellowiſh, ſomewhat fetid, mucilaginous, and liquid pulp. That which is firſt prepared and turned fluid, goes before the reſt out of the ſtomach; firſt water; then milk, pot-herbs, bread; and laſt of all, fleſh-meats, the harder, tougher, and longer ſkins or fibres of which paſs unchanged: but ſuch things as are hard, or too large to paſs the pylorus, are retained in the ſtomach for a long time.

DCLII. But a conſiderable portion of the drink is abſorbed by the pendulous inhaling veins of the ſtomach itſelf, gaping like the exhaling arteries of the ſame part (DCXXXIII.); ſo their contents take a ſhorter way into the blood, as plainly appears from repeated experiments of injecting the veins. Does any thing paſs into the lymphatic veſſels (DCXXXI.)?

DCLIII. The ſtomach, being irritated by too great a quantity or acrimony of the food, or elſe by ſickneſs, a repulſion of the bile, or other cauſe, does, by an antiperiſtaltic or reverted motion of its fibres, drive its contents upward, through the open and relaxed œſophagus, in the act of vomiting[155]. But then this effect is partly from the preſſure of the abdominal muſcles, depreſſing the falſe ribs, and urging the contents of the abdomen againſt the diaphragm; which at the ſame time contracting itſelf to a plain downwards, forces the ſtomach, as betwixt the ſides of a preſs, to throw up its contents.

DCLIV. But the aliments, driven in their natural courſe to the duodenum, meet there with the influent bile and pancreatic juice, which often flow back into the ſtomach. But the former of theſe being the principal baſis of chylification, will require from us a previous hiſtory of the viſcera, which convey their blood through the vena porta.

CHAP. XXI.

Of the OMENTUM.

DCLV. BY the *peritonæum*, we underſtand a ſtrong ſimple membrane, by which all the viſcera of the abdomen are ſurrounded, and in a meaſure ſuſtained,

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[155] Any part of the whole inteſtinal canal, from the pharynx to the rectum, may be conſtricted, as well ſlowly as ſuddenly, by an antiperiſtaltic motion. If it happens ſuddenly to the upper parts at

tained. Internally this membrane is exceedingly ſmooth, and moiſtened with exhaling vapours: but outwardly it adheres to all the parts by the looſe cellular ſubſtance; which, towards the kidneys, contains a good deal of fat; but is extremely thin and ſhort before, betwixt the peritonæum and tendons of the tranſverſe muſcles of the abdomen. It begins from the lower ſide of the diaphragm, which it lines; and in certain intervals, joining with the correſponding pleura above, it completes what would be otherwiſe deficiencies in the diaphragm, as betwixt the ultimate fleſhy fibres next the ribs and at the loins; to which add, its continuations upward, through the foramina of the diaphragm. From thence this membrane deſcends, in its fore-part, behind the abdominal muſcles; in its back part, before the kidneys; and, going into the pelvis, from the bones of the pubes, it paſſes over the bladder obliquely backward; and then reaſcends back over the ureters by two lunar folds or plates, rejoining upon the inteſtinum rectum with that part of itſelf which inveſted the loins, and in the ſame place goes before the rectum.

DCLVI. The cellular texture which covers the peritonæum on the outſide, is continued into ſheaths in very many places; of which one receives the teſticle on each ſide; another the iliac veſſels; others the inteſtinum rectum, the larger veſſels of the pelvis, the obturatoria, penis, bladder, and aorta, and accompany the gullet, aſcending into the breaſt, and along the vertebræ; by means of which, there is a communication between the whole body and the peritonæum, very remarkable in dropſical people.

DCLVII. But through this general extent, it ſends out various productions for covering the viſcera. The ſhorter productions of this membrane are called *ligaments;*

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at the ſtomach, the ſeptum tranſverſum being at the ſame time convulſed, and likewiſe the abdominal muſcles, it is called *vomiting*. If it is ſlowly performed, it may be called *ruminatio*. If the ſmall, and particularly the great inteſtines, return their contents upwards, the diſeaſe is called *ileus*.

ments; and are all of them formed by a continuous reduplication of the peritonæum, coming from its inner ſurface, together with a cellular ſubſtance, interpoſed and extending to ſome one or other of its viſcera, where its plates ſeparate again from each other to embrace the organ, which they are to ſurround and furniſh with a coat; but the cellular ſubſtance always intervenes betwixt this membranous coat of the peritonæum, and joins with it the true fleſhy ſubſtance of the viſcus. Of productions of this kind, there are three ſhort ones belonging to the liver, one or two to the ſpleen, and others to the kidneys and lateral parts of the uterus and vagina. By this means the tender ſubſtance of the viſcera is defended from injury by any motion or concuſſion; and their whole maſs is prevented from being miſplaced by their own weight, by their firm connection with the peritonæum.

DCLVIII. But the moſt noted of all theſe productions from the peritonæum, are thoſe called the *meſentery* and *meſocolon;* the deſcription of both which, although difficult, ought not to be ſeparated from that of the peritonæum itſelf. We ſhall, therefore, begin firſt with a deſcription of the *meſocolon*, as being the more ſimple. In the pelvis, the peritonæum ſpreads itſelf within a ſhort compaſs before the rectum; but where that inteſtine bends into a ſemilunar curve, the peritonæum there departs out far from the iliac veſſels and ſeat of the pſoas muſcle which lie upon the muſcles of the loins, and ariſes as if duplicated (DCLVII.), ſpreading itſelf in ſuch a form as is fitteſt to receive the colon into its capacity. But above, on the left ſide, that the colon might be at liberty, it is conjoined to the peritonæum, with little or none of this middle production; ſpreading itſelf upon the body of the pſoas muſcle, as high as the ſpleen, where this part of the peritonæum, that gave a coat to the colon ſpread under the ſpleen, receives and ſuſtains that viſcus, by taking it into its capacity or folds.

DCLIX. Then the peritonæum aſcends forwards from both kidneys, the interjacent ſpaces between them, and from the large blood-veſſels, under the pancreas; to which being continuous, it forms a long production, called the *tranſverſe meſocolon*, which, like a partition, divides the upper part of the abdomen, containing the ſtomach, liver, ſpleen, and pancreas, from its lower cavity. The lower plate of this tranſverſe production is ſingle, continued from the right to the left meſocolon, and ſerves as an external coat to a large portion of the lower and deſcending part of the duodenum. But the upper plate, taking a more obſtructed courſe, departs from the lumbar peritonæum at the kidney and ſeat of the vena cava, farther to the right than the duodenum, to which it gives an external membrane, not quite to the valve of the pylorus; and, beyond this inteſtine and the colon, is joined with the lower plate in ſuch a manner, that a large part of the duodenum lies within the capacity of the meſocolon. Afterwards, near the liver, the meſocolon bends itſelf inward, and deſcends laterally over the kidney of the ſame ſide ſo as to include the right colon, which is much ſhorter than the left, even as far as the inteſtinum cæcum, reſting upon the iliac muſcle; to the appendicle of which, a peculiar long detachment adheres, as a beginning to the meſentery. There the meſocolon terminates almoſt at the bifurcation of the aorta.

DCLX. The whole meſocolon, and the whole meſentery, is hollow; ſo that air may be forced in between its two ſimilar plates in ſuch a manner as to expand it into a bag. At the place where the colon ſuſtains it, and alſo from part of the inteſtinum rectum, the meſocolon, which is continuous with the outer membrane of the inteſtine, forms itſelf into ſmall ſlender bags, for the moſt part double, thick, and bifid, free at their extremities, and capable of admitting air driven in between the plates of the meſocolon.

DCLXI. From thence forward the *meſentery* follows, as a broad plaited production of the peritonæum, continuous with the tranſverſe meſocolon, and extended on the right ſide forward, and downward from the emerging duodenum; and then from the left or long meſocolon, even as low as the pelvis. Thus the meſentery is formed by the plates of the peritonæum, which lie upon the aorta, extended forward and together, under the right portion of the tranſverſe meſocolon; and, deſcending obliquely under the pancreas, it contains the long ſeries of the ſmall inteſtines, within its capacity, diſpoſed in numberleſs folds.

DCLXII. The whole ſeat and extent of the meſentery and meſocolon contains a portion of fat, collected in greater quantity as they go farther within the capacity that is neceſſarily formed by the reduplication of their membranes, and veſſels are interſperſed ſurrounding the fat, which the arteries ſeparate, and the veins, as will be mentioned, reabſorb; there are alſo very numerous glands, which are moſt conſpicuous in a young perſon.

DCLXIII. The ſtructure of the *omentum* anſwers very nearly to that of the meſentery. But there are many membranes that come under this general denomination, of the ſame ſtructure and utility, all compoſed of very tender and fine membranes, eaſily lacerated, betwixt which the blood-veſſels are diſpoſed reticularly, with fat depoſited in ſtreaks near the ſides, and in the ſame directions with the reticulated veſſels themſelves. This membrane is always double; the two plates of which are joined together cloſely by a very tender cellular ſubſtance, within which the veſſels are diſtributed, and the fat collected. And, firſt, where the top of the right kidney and the inſulcated lobe of the liver, together with the ſubjacent blood-veſſels, meet with the duodenum into an angle, there the external membrane of the colon, which comes from the peritonæum, joining with the other membrane of the duodenum, which is alſo from the adjacent peritonæum, they go together over the left kidney backward, and enter into the tranſverſe fiſſure of the liver, for a conſiderable length; from which the external membrane is continued over the gall-bladder which it contains, confining the vaſcular fabric of the liver, very ſlippery, and tinged of a yellow colour. Behind this membranous production, betwixt the adjacent duodenum, right lobe of the liver, hepatic veſſels, vena portarum, and biliary ducts and artery, lies a ſmall natural opening, by which inflated air is largely received into all that cavity of the omentum which we ſhall preſently deſcribe as a bag; and, laſtly, into the bags of the reſt of the omentum.

DCLXIV. From thence in a courſe continuous with this membrane (DCLXIII.) from the pylorus and the leſs curve of the ſtomach, the outer membrane of the liver joins in ſuch a manner with that of the ſtomach, that the thin membrane of the liver is continued out of the foſſa of the venal duct, before the little lobule, into the ſtomach itſelf, ſtretched both before the lobule and before the pancreas. This is called the *little omentum hepatico-gaſtricum;* which, inflated, reſembles a cone; and, hardening by degrees when it is without fat, changes into a true ligament, by which the œſophagus and liver are conjoined together (DCXXIII.)

DCLXV. But the great *gaſtrocolic-omentum* is of a much larger extent. It begins at the firſt joining of the right gaſtro-epiploic artery to the ſtomach, where it is continued from the upper plate of the tranſverſe meſocolon (DCLIX.); and from thence it proceeds forward along the great arch or curve of the ſtomach to the ſpleen, and in part is continued alſo from the right convex end of the ſtomach towards the ſpleen, even till it degenerates into a ligament that ties the upper and back part of the ſpleen to the ſtomach. This is the *anterior leaf* of the omentum.

DCLXVI. This anterior leaf or lamina of the omentum floats looſely downward before the inteſtines, ſometimes to the navel, ſometimes to the pelvis, behind the muſcles of the abdomen; and, making a thin edge, is folded back again in a direction contrary to itſelf, and aſcends ſo as to leave an intermediate vacuity, by which the fore leaf is removed from the poſterior; and being at length continued for a conſiderable extent into the outer membrane of the tranſverſe colon, and laſtly continued in the ſinus of the ſpleen by which the larger blood-veſſels are received, it ends in the œſophagus, under the diaphragm. Behind the ſtomach, and before the pancreas, the cavity of this is continued into that of the leſſer omentum.

DCLXVII. To this is continued the omentum colicum, which ariſes on the right ſide only from the colon and its external membrane, immediately after the origin of the omentum gaſtrocolicum from the meſocolon, with whoſe cavity it is continuous, but produced by the colon and its membrane, which departs doubled from the inteſtine, forms a production ending conically, and is terminated by a longer or ſhorter extent above the inteſtinum cæcum.

DCLXVIII. The uſes of the omentum are many. Its common uſe is, together with that of the meſentery, to form an ample ſpace, of a looſe texture, into which the fat may be poured from the arteries, at the time of ſleep and inactivity of body, to be afterwards diſſolved by motion, and returned again into the blood by the inſorbent veins, ſo as to make a conſtituent principle of the bile. Accordingly, you will feel the fat of the omentum to be very tenacious or viſcid betwixt the fingers, although of a thin conſiſtence, and in its whole body more pellucid than paper. For that the fat of this part returns again into the veins, appears from the different bulk and weight of fat obſervable in the various omenta of different perſons, according as they lead either an idle, laborious, or morbid courſe of life; to which add, its appearances in various brute animals, with the relation it bears to all the reſt of the fat of the body (XX.): from experiments in frogs, where this re-abſorption of the fat may be made evident to the eye: and, laſtly, from the apparently inflammable nature of the bile itſelf. To this we muſt alſo refer the diſorders and crudities of digeſtion, together with the

cold-

coldneſs of the ſtomach, obſerved to follow after cutting out the omentum.

DCLXIX. For all the blood which returns from the omentum and meſocolon, goes into the trunk of the vena portarum, and by that into the liver itſelf. The omentum is furniſhed with blood by the gaſtrocolic and by each of the gaſtro-epiploic arteries, deſcending in many ſmall branches, and ſubdivided in a reticular manner: of theſe, the arteries on each ſide run to the greateſt length; but the inner or poſterior leaf of the omentum has ſmall arteries, which go out from thoſe of the colon. Branches alſo come to it from the ſplenic, duodenal, and adipoſe arteries. The omentum colicum has alſo its arteries from the colon, in the ſame manner as the ſmaller appendices (DCLX.) The arteries of the leſſer omentum come from the hepatics, alſo from the right and left coronaries of the ſtomach.

DCLXX. The nerves of the omentum are very ſmall, as being a fat and indolent body; yet it receives ſome little branches from the nerves of the eighth pair, both in the greater and in the leſſer curve of the ſtomach.

DCLXXI. The arteries of the meſentery are, in general, the ſame with thoſe that go to the inteſtines; the ſmaller branches of which go to the ſmaller glandules and cellular fat included within the meſentery. But, to the meſocolon, ſmall arteries are diſtributed on all ſides from thoſe of the various parts connected to it; as the intercoſtals, ſpermatics, lumbals of the renal capſules, and tranſverſely from the ſplenic artery, with the pancreatic branch of the duodenum: but, in the left meſocolon, there are alſo ſmall arteries detached from the aorta itſelf to the glandulæ lumbales.

DCLXXII. The veins of the omentum, in general, accompany the arteries, and unite into ſimilar trunks; thoſe of the gaſtrocolic omentum from the left ſide open into the ſplenic, as do thoſe of the hepaticogaſtric, which likewiſe ſends its blood to the trunk of the vena portarum: thoſe from the larger part of the right gaſtrocolic omentum go to the meſenteric trunk; as do thoſe of the omentum colicum, with thoſe of the appendices epiploicæ. All the veins of the meſentery meet together in one, which is truly the trunk of the vena portarum: in forming which, they are firſt collected into two large arms; of which one receives the gaſtro-epiploica, with the middle colic and iliocolic veins, and all thoſe of the ſmall inteſtines as far as the duodenum; the other arm, which goes tranſverſely acroſs the former, that ariſes above it, is embraced by the duodenum, and returns the blood of the left colic veins, with thoſe of the rectum, except the lowermoſt, which belong partly to thoſe of the bladder, and partly to the hypogaſtric branches of the pelvis. The vein which is commonly called *hæmorrhoidalis interna*, is ſometimes inſerted rather into the ſplenic than into the meſenteric vein. If it be demanded, Whether the omentum has any lymphatic veſſels? we anſwer in the affirmative: ſince there are conglobate or lymphatic glandules, both in the little omentum and in the gaſtrocolicum; alſo the ancient anatomiſts have obſerved pellucid veſſels in the omentum; and, lately, a modern has deſcribed them for lacteals of the ſtomach.

DCLXXIII. Other uſes of the omentum are, to interpoſe betwixt the inteſtines and peritonæum, which, by inflammation, are very apt to grow together; to keep the former in a ſtate of free motion, as well among themſelves as againſt the peritonæum, with but little attrition; and to anoint the muſcular and membranous fibres with a very ſoft oil. For theſe reaſons, even in inſects, there is a great deal of fat placed round the inteſtines. In the large inteſtines, there are a great many appendices, which likewiſe are produced from the large branches, and cannot altogether cover the omentum. But the ſame ſets the veſſels in order; conducts and gives them ſtrength; and exhales a ſoft vapour, which, mixed with the exhaling abdominal water, anoints and lubricates all the viſcera.

DCLXXIV. The meſentery ſerves to ſuſpend and diſplay

play the inteſtines in ſuch a manner, that they may move freely, and with a degree of firmneſs: it ſerves as a bed to ſuſtain, and ſafely conduct the numerous veſſels, nerves, and glandules; of which laſt we ſhall ſpeak hereafter: it alſo gives an external coat to the inteſtines, and forms moſt of the omenta.

DCLXXV. But, beſides, the blood, returning thro' the meſenteric and meſocolic veins, brings with it another principal conſtituent part of the bile; namely, a ſub-alkaline watery humour, which is abſorbed by the veins from all the ſmall inteſtines, as will be demoſtrated in its proper place. Beſides this, it gives to the liver a more putrid water from the large inteſtines, which is fetid, and nearly approaches to a volatile alkaline nature, abſorbed from the feces, that now begin to ſmell ſtrong; the exiſtence of which is eaſily proved, both from our own experiments, and the drying of the feces when too long retained. The water is, therefore, a fluid in itſelf, and rendered more ſo by an incipient putrefaction; and, conſequently, it ſerves to reduce the tenacity of the oil belonging to the omentum and meſentery, ſo as to keep it from congealing. But more eſpecially in the bile, it conſtitutes the rancid alkaline quality, with which this humour abounds; and from thence comes the great tenuity and tinging ſaponaceous quality of the bile.

CHAP. XXII.

Of the SPLEEN.

DCLXXVI. THE ſpleen itſelf is one of thoſe viſcera, which ſend their blood to the liver. It is a blueiſh, pulpy, ſomewhat oval viſcus, ſomething like a maſs of congealed blood in its conſiſtence, having frequently a notch or inciſure in its oval circumference; whence it is convex towards the ribs, concave niwardly, and circumſcribed with two margins or edges, of which the inferior and anterior is the ſharpeſt. It is connected to the ſtomach by the little omentum; and above that, by the upper ligament, ſupported by the ſubjacent colon, and by another ligament (DCLVIII.)

behind the renal capſule; to which, and to the kidneys, it adheres by the peritonæum. It alſo receives the peritonæum from the diaphragm, under the denomination of a ligament, in the back part of its hollow ſinus, behind its veſſels. The ſituation of it varies with that of the ſtomach itſelf, which it follows. When that is empty, the ſpleen is raiſed perpendicularly, ſo as to place its extremities right up and down: but when the ſtomach is full, the middle curve or arch of it ariſes upward and forward (DCXXII.); and at the ſame time obliges the ſpleen to change its ſituation, ſo as to lie almoſt tranſverſely with its lower end forward, and its upper end backward. Thus, being of a very ſoft and looſe texture, it grows larger by diſtention when the ſtomach is empty, and becomes leſs again when its blood is preſſed out by the diſtention of the full ſtomach againſt the ribs. From hence the ſpleen is found large in thoſe who die of lingering diſeaſes; but in thoſe who die ſuddenly, and in full health of body, it is ſmall. Another motion of the ſpleen is, that of deſcending with the diaphragm in inſpiration, and aſcending again in exſpiration; and beſides this, the ſpleen frequently varies in its ſituation with that of the colon. Frequently there is a ſecond or leſs ſpleen placed upon the former.

DCLXXVII. The *blood-veſſels* of the ſpleen are large, in proportion to its weight. The arterial trunk comes from the cœliac; the upper branch of which, proceeding in a ſerpentine courſe above and behind the pancreas, to which it gives branches, as well as to the meſocolon, ſtomach, and omentum, is at length incurvated in the direction of the ſulcus or notch of the ſpleen, which it, after a manner, perforates by ſeveral diſtinct branches, ſuſtained at the right extremity by the omentum gaſtrocolicum. The thickneſs of this artery is greater than that of the aorta. The ſplenic vein, which accompanies the artery, is conſiderably ſofter than any other veins of the body; it forms the principal left branch of the vena portarum. Beſides theſe, the ſpleen re-

receives ſmall arteries from the great coronary deſcending behind the pancreas, and ſometimes from the internal hæmorrhoidal. The vaſa brevia of the ſpleen and ſtomach we have mentioned elſewhere; and its ligaments and membranes receive ſmall arterial twigs from the lumbar arteries, phrenics, intercoſtals, and thoſe of the renal capſules. In like manner alſo the veins in the ſpleen, and thoſe which join it to the ſtomach, communicate with the phrenics, and with the veins of the renal capſules.

DCLXXVIII. The *lymphatic veſſels* of the ſpleen are deſcribed to ariſe in the duplicature of the ſplenic coat or membrane [156] (of which there is none at all), and from thence to proceed on to the receptacles of the chyle, very evident in a calf; in mankind they are rendered conſpicuous by blowing air under the membrane, by maceration, or water injected into the arteries.

DCLXXIX. The *nerves* of the ſpleen are very ſmall; from whence it is capable of but little pain, and is very rarely inflamed. They ariſe from a particular plexus, compoſed out of the poſterior branches of the eighth pair at the ſtomach (DCXXX.), and of certain branches from the large gangliform plexus, which produces the ſplenic trunk of the intercoſtal nerve, from whence the branches ſurround the artery into the ſpleen.

DCLXXX. The fabric of the ſpleen appears to be much more ſimple than has been commonly believed. For it is compoſed, both in us and in calves, altogether of arteries and of veins; the former of which, after ſpending themſelves in a great number of ſmall branches, are at length thickly ſubdivided into very ſoft bruſh-like bunches, very difficult to fill with injection, terminating in circles; by which there is a ready paſſage for liquors into the correſponding veins. Theſe circles, with their parallel branches, form a ſort of bunches like a pencil bruſh, but of a ſhorter rounder kind; whence many have miſtaken them for glands. Nor does the injection, rightly managed, ever eſcape from the veſſels into the intervals; nor were any hollow glandules ever diſcovered by certain obſervation. Every little arterial trunk, with the ſmaller twigs that proceed from it, are each of them ſurrounded by a very fine cellular ſubſtance or web-work, in the ſame manner with the ſmall veſſels of all the other viſcera, but here rather ſofter. The whole body of the ſpleen is outwardly ſurrounded by a ſingle membrane, which is not very tough, continued from the peritonæum, and joined to the fleſhy part of the ſpleen by a pretty thick cellular texture.

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[156] The reaſon why Haller denies this, ariſes from this error: That the proper tunic of the ſpleen comes from the peritonæum; which however is not the caſe. The ſpleen, like the kidneys, has a membrane of its own, over which a piece is continued from the peritonæum; from thence ariſes a true duplicature, containing a plexus of lymphatic veſſels.

DCLXXXI. Hence we obſerve, that the ſpleen contains more blood, in proportion, than any of the other viſcera; ſince it has no muſcles, fat, air-veſſels, or excretory ducts, interpoſed betwixt its blood-veſſels. We learn alſo from obſervation, that the blood of this part hardly ever congeals, from the abundance of its volatile or bilious ſalts: but it looks of a dark-brown colour, and may be eaſily diluted; whence one may compare it almoſt to the blood of a fœtus.

DCLXXXII. The want of an excretory duct to the ſpleen, has occaſioned the uſe of it to be doubtful, and controverted throughout all ages of anatomy. To us the fabric itſelf ſeems to lead to the following uſes; although, perhaps, they do not comprehend all the uſes of the ſpleen. A great quantity of blood is imported to the ſpleen (DCLXXVII.), and with a ſlower motion, from the ſerpentine courſe and hardneſs of the artery: but, at the time when the ſtomach is empty, this blood comes, and is received in a greater quantity by the ſpleen, not now ſo much compreſſed, therein to ſtagnate, as it would ſeem plainly from the great proportion of branches to the trunks in this part; to which add, the difficult courſe or ſlow circulation which the blood meets with in paſſing from the ſpleen through the liver: from hence the frequent ſcirrhoſities of the ſpleen;

and from hence the immenſe quantity of blood with which the ſpleen is in every point diſtended, the like of which we do not ſee in any other part. Here, then, the almoſt ſtagnant blood, fomented with heat, attenuated, and in a manner diſſolved by the putrid feces of the adjacent colon, enters thus upon the firſt ſteps of a begun putrefaction, as we learn by experiments, both from its colour and conſiſtence. But the greater fluidity of the blood herein, proceeds not only from this diſſolution, but becauſe all its watery juices that enter by the artery return alſo again by the vein; for there are no ſecretory ducts in the ſpleen.

DCLXXXIII. Moreover, when the ſtomach is full of food or flatus, the ſpleen is thereby compreſſed into a narrower compaſs, againſt the ribs and ſuperincumbent diaphragm, by which means the blood, that before was ſcarce able to creep along through the ſplenic veins, being now preſſed out more plentifully, returns with a greater celerity towards the liver; till mixing with the ſluggiſh blood in the trunk of the porta, repleniſhed with the fat or oil of the omentum and meſentery (DCLXIX.), it dilutes or thins the ſame, and renders it leſs apt to ſtagnate or congeal; and at the ſame time it conduces to form a larger ſecretion of bile at a time when it is moſt wanted, viz. to flow plentifully to the food now under digeſtion. The ſpleen, therefore, ſeems to prepare the blood, that it may ſupply a ſort of watery juice to the bile; but ſuch as is probably of a ſubalkaline nature, and rendered ſomewhat ſharp by the remora of the blood.

DCLXXXIV. Whether is the ſpleen of a cellular fabric? Is the blood poured out into thoſe cells ſo as to ſtagnate? or is it diluted with ſome juice ſecreted by peculiar glands? We ſee nothing of this is demonſtrable by anatomy; nor does the liquor or wax injected ever extravaſate into the cellular ſubſtance, unleſs urged with much greater violence than nature ever uſes or intended. As to the old queſtion, Whether the ſpleen brews up an acid to whet or ſharpen the ſtomach?

that opinion has been long diſcarded, as repugnant to the nature of all the animal juices. If it be aſked, Whether the ſpleen be not an uſeleſs maſs, as it might ſeem to be, from the little damage an animal ſuſtains after it has been cut out? we anſwer, That a robuſt animal, ſuffering but little injury from the loſs of a part, does not prove it to be uſeleſs; and yet there are examples, after ſuch an experiment has been made, that the liver becomes ſwelled and diſordered, makes a leſs quantity of bile, and of a darker brown colour; while the animal is perpetually troubled with flatulencies, gripes, or indigeſtion: all which are to be aſcribed to the vitiated nature of the bile, an obſtruction of the liver, and an imperfect or weak digeſtion; at they ſame time they are confirmed by repeated experiments.

CHAP. XXIII.

Of the PANCREAS.

DCLXXXV. THE pancreatic *juice*, which is watery, inſipid, thin, neither acid nor alkaline, is poured into the ſame place into which the bile diſcharges itſelf.

DCLXXXVI. The *pancreas* is a very long glandule, the largeſt of the ſalival kind, extended over the inferior lamina of the tranſverſe meſocolon; which, beyond the pancreas, behind its ſuperior lamina, behind the ſtomach, before the ſpleen, under and behind the liver, meets with the inferior lamina: it lies before the left capſule and the aorta; is plain, and of a triangular ſhape, with a light ſtroke on the upper part, and covered with the peritonæum, upon which the poſterior flat ſide of the empty ſtomach is ſupported; for that ſide of the ſtomach is both lower as well as poſterior. The pancreas begins ſmall from the ſpleen itſelf; and extending almoſt tranſverſely towards the right ſide, it emerges forwards to the peritonæum, acroſs the vertebræ, to the right ſide of which it grows conſiderably broad, being received betwixt the ſuperior and inferior plate of the tranſverſe meſocolon (DCLIX.); and is, finally, ſo connected by its round head to the duodenum, that this inteſtine ſerves it for a meſentery. The ſtructure of it is, like that of the ſalival glands, made up by a great number of ſmall kernels of a firm texture, connected to each other by a good deal of cellular ſubſtance. The pancreatic *blood-veſſels* are rather numerous than large, derived chiefly from the ſplenic branches: but on the right ſide it is ſupplied by the firſt artery of the duodenum, and from that other which is lower down, and is in common both to the duodenum and pancreas; both of which ariſe from the hepatic artery, and of which the former inoſculates with the latter, and both with the meſenteric artery, which ſupplies conſiderable twigs to this gland; but the ſmaller ramifications come from the phrenic and capſular arteries. The *nerves* of this gland are not of any conſiderable ſize; whence it is but little ſenſible: they are derived from the poſterior gaſtric and the hepatic plexus, from that of the ſpleen, &c.

DCLXXXVII. The *excretory duct* of this gland runs almoſt through its middle, white and tender, ariſing every where from a great number of roots; by which, being gradually increaſed, it emerges before the vena portarum and meſenteric artery, and receives a large branch from the lateral pancreatic portion; from whence it advances to the ſame part of the duodenum into which the biliary duct opens; where, changing its courſe downward, it enters through the ſinus that lies betwixt the coats of the inteſtine, internally ſmooth; and here, receiving the ductus choledochus, it opens together with that into a certain fold of the ſame duodenum, deſcending towards its loweſt part. But not unfrequently it opens diſtinct, both in its duct and orifice, from that of the biliary duct; and ſometimes it is inſerted by two ducts, of which the lower one only is diſtinct and leſs; but in man, and moſt other animals, it always opens near the duct of the bile. In its mouth there is no bile.

DCLXXXVIII. The quantity of juice ſecreted by this gland is uncertain: but it muſt be very conſiderable, if we compare the bulk or weight of it with that of the ſalival glands; than which it is three times larger, and ſeated in a warmer place. It is expelled by the force of the circulating blood, with an alternate preſſure from the incumbent and ſurrounding viſcera; as the liver, ſtomach, ſpleen, meſenteric and ſplenic arteries, with the aorta. The great uſefulneſs of this gland may appear from its being found not only in man, but almoſt in all animals: nor is its uſe the leſs from that experiment which ſhows a great part of it may be cut out from a robuſt animal without occaſioning death; becauſe, in the experiment, a part of the pancreas muſt be left with the duodenum. Its effervеſcence with the bile ariſes from the effect of a ligature, and air mixed with the inteſtinal humour.

DCLXXXVIII. The pancreatic juice ſeems principally of uſe to dilute the viſcid cyſtic juice, to mitigate its acrimony, and mix it with the food. Hence it is poured into a place remote from the cyſtic duct as often as there is no cyſtis. Like the reſt of the inteſtinal humours, this juice dilutes the maſs of aliments, reſolves them, and does every other office of the ſaliva.

CHAP. XXIV.

Of the LIVER, GALL-BLADDER, *and* BILE.

DCLXXXIX. THE *liver*, being the largeſt of all the viſcera, fills up a very large part of the abdomen in its upper chamber, above the meſocolon; and is ſtill larger in proporton in the fœtus. Above, behind, and to the right ſide, it is covered by the ſuperincumbent diaphragm, from which it receives the peritonæum for a covering, under the denomination of ligaments, chiefly in three places; for on the convex part of the liver, from the paſſage of the vena cava to the tranſverſe furrow of the liver, the peritonæum deſcends double, growing broader in the forepart,

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under the name of *ligamentum ſuſpenſorium*, which divides the greater right lobe from the leſſer left lobe of the liver; and then parting from its duplication, it expands into the proper coat of this viſcus (DCXXIII.), which is white, ſimple, and thin, like the external coat of the ſtomach; and under this ſpread the cellular ſubſtance, by which it is intimately conjoined with the fleſh of the liver. To the lower margin of this, joins the umbilical vein; which, in an adult, being dried up, leaves only a ſmall cord, ſurrounded with much fat. In the extremity of the left lobe, and on the convex part, not unfrequently at its edge, a membrane goes to the liver from the diaphragm; which in children, and other young ſubjects, is frequently to the left ſide of the œſophagus, but in adults to the right ſide; yet always conjoined both to the gula and to the ſpleen, whenever the liver or the left ligament is very large. The right ligament ties the diaphragm in its hinder part to the thickeſt part of the right lobe. Beſides, but without any apparent length, the membrane of the right lobe of the liver is often conjoined by the cellular ſubſtance with the diaphragm; more eſpecially in old ſubjects, for in the fœtus it is eaſily ſeparated; and then it continues it courſe betwixt the ſuſpenſory and left ligament, joined as before with the peritonæum, ſo as to reſemble a ligament. But alſo from the right kidney, the peritonæum going off to the liver, makes a reduplication like a ligament, and conjoins together the leſs omentum with the continued looſe productions of the meſocolon (DCLXIII.) with the liver, ſtomach, and duodenum; and likewiſe the ſame meſocolon to the pancreas. Thus the liver is ſuſpended in the body, with a conſiderable degree of firmneſs; yet ſo as to be allowed a conſiderable liberty to move and be variouſly agitated, raiſed, and depreſſed, by the actions of the diaphragm. The ſame ligaments form a common membrane, which covers the liver as well as other viſcera.

DCXC. Moreover, the inner concave face of the right liver lies with its forepart before the colon; and in its back part correſponds to the right kidney and renal capſule, to which it is connected by the cellular ſubſtance. The middle ſinus lies near the duodenum, which touches the gall bladder; and alſo lies contiguous with that part that conducts the great blood-veſſels. The left lobe extends largely over the ſtomach; and frequently, eſpecially in younger ſubjects, goes beyond the œſophagus into the left hypochondrium. The lobule, in the mean time, adapts itſelf to the leſſer curve of the ſtomach. But, moreover, the pancreas is covered by the liver, and the right renal capſule is tied to the part of the liver fartheſt to the right ſide by much cellular texture.

DCXCI. The figure of the liver is difficult to deſcribe. It begins in the cavity of the right hypochondrium, by a very thick ſolid protuberance, convex towards the diaphragm, and hollow towards the colon and kidney; having a protuberant line dividing the faces of theſe ſmall hollows, which is continued to the longer appendix of the lobule. After this, the liver grows ſlenderer and thinner, and is at laſt terminated or extenuated into a tip, almoſt triangular; which, paſſing into the left hypochondrium, goes before the œſophagus, in young ſubjects, as far as the ſpleen; but in adults, it is often ſhorter, and ends at the œſophagus. The edge, in which the convex part of the liver meets with the concave one, is wholly in the fore and lower part. The whole obtuſe margin lies backward. The upper and back part of the liver is every where convex; ſuſtains the diaphragm; and in a large part, which is ſomewhat flatter, towards the left ſide, it is placed under the heart: but the lower ſurface, being variouſly figured, reſts itſelf upon the duodenum, colon, ſtomach, pancreas, and right renal capſule. For there are ſeveral little furrows which divide the ſurface into different regions, and which did not eſcape the notice of the ancients.

DCXCII. The principal of theſe furrows is extended tranſverſely, from the right ſide to the left, and divides a third part of the liver, beginning ſlender in the right lobe, and growing broader towards the left. Before this tranſverſe ſulcus, there is an excavation in the right lobe for the gall-bladder, and then the anonymous convex lobule; after which comes the foſſa of the umbilical vein, extending tranſverſely backward, often covered with a proceſs or bridge that joins the anonymous to the left lobe; but behind the great ſulcus, firſt towards the right ſide, there is a ſlender tranſverſe eminence growing broader to the right, and moderately hollow, by which the great blood-veſſels are conducted into the liver: and this little valley was by the ancients denominated the *portæ* or gates of the liver. This joins the lobule, which I ſhall deſcribe, with the right lobe. Then the poſterior lobules, ſhaped like a nipple, obtuſely conical, projects into the leſs curvature of the ſtomrch. The thick root of this and the former excavated eminence, begins from the convex part of the liver, at the diaphragm; and from thence, on the right ſide, is impreſſed with an oblique furrow, inclined to the right ſide, for the paſſage of the trunk of the vena cava, deſcending from the heart to the lumbal vertebræ; and is frequently ſurrounded by a great part of the fleſh of the liver, like a bridge, or even ſo as to complete the circle, and form a tube. The left end of the lobule is terminated by another foſſa almoſt ſtraight backwards, but inclined to the left; which, taking its origin from the extremity of the tranſverſe one, terminates at the paſſage of the vena cava through the diaphragm. In this ſinus was lodged the ductus venoſus in the fœtus, of which there are ſome remains to be perceived alſo in the adult. All that lies beyond this is the left lobe, which is ſingle, equally concave below, ſo that it may lie upon the ſtomach, and is extenuated to a thin edge.

DCXCIII. This ſo large viſcus is proportionably ſupplied with veſſels, and of various kinds. The artery, which is indeed conſiderable, being the greater right portion of the cæliac, emerges from the trunk forward, and to the right, going tranſverſely before the vena portarum; and after giving off a ſmall coronary with the pancreatic and duodenal artery, the laſt of which is pretty large, it goes on and enters the liver, commonly by two branches; of which the left is betwixt the umbilical foſſa, the venal duct, poſterior lobule, with the left and the anonymous lobe, alſo the ſuſpenſory ligament; and this branch inoſculates with the phrenic and epigaſtric arteries. The right enters the liver lower, covered by the biliary ducts; and having reached the right with the anonymous lobe, there ſends off, in one ſmall trunk, the cyſtic artery, which ſoon after divides into two, and is ſpread both under and upon the gall-bladder, covered by the common coat of the liver, and ſupplies not only the gall-bladder and biliary ducts with its branches, but likewiſe ſome part of the liver itſelf. From the left branch, or ſometimes from the trunk of this, ariſes a ſuperficial artery to the biliary ducts, anonymous lobe, and glandules of the portæ. Beſides the cæliac artery, there is frequently a large right branch produced from the meſenterica major, creeping behind the pancreas; and this ſerves inſtead of the eighth branch of the hepatic artery from the cæliac. But likewiſe, the greater coronary, which is the firſt twig of the cæliac, always gives ſome ramifications to the left lobe, and to the foſſa of the ductus venoſus; which laſt branch is often very conſiderable. The leſſer arteries are thoſe ſent to the liver from the phrenic, mammaries, renal and capſular arteries. They communicate alſo with the epigaſtrics.

DCXCIV. In the fœtus, the umbilical vein brings much blood to the liver, at which time the vein ſtretching to the portæ is but ſmall. It ſends forth branches while it ſtretches backwards through its foſſa; theſe branches are numerous, and very large; ſo that one of them equals the vena portarum in bigneſs, in that place where it is dilated into a tumour, which unites with the left branch of the vena portarum. But it ſends one branch through the poſterior part of the horizontal foſſa into the vena cava, or ſome of its hepatic branches: this is called the *ductus venoſus*. In an adult perſon, indeed, this duct is filled up; and the vena portarum, which now grows larger, fills the hepatic branches.

DCXCV. The vena portarum receives all the blood of the ſtomach (DCXXIX), of the inteſtines and meſentery (DCXXXI.), of the ſpleen (DCLXXVII.), omentum (DCLXIX.), and, laſtly, of the pancreas, at firſt into two trunks, the tranſverſe ſplenic and aſcending meſenteric; then into one, which is continued with the meſenterics. This is large, compoſed of ſtrong membranes, firſt a little bent behind the duodenum, where it receives the vein from its right ſide, together with the leſſer coronary; whence going higher to the right ſide, it again divides into two large trunks in the ſinus of the lobule of the liver (DCXCII.), and immediately after is again divided into two large trunks. Of theſe two, the right, being ſhorter, larger, and bifurcated, having received the cyſtic vein, goes to its own lobe. The left runs on through the remaining part of the tranſverſe furrow of the liver; and after giving veins to the lobule, with the anonymous and left lobe, it is incurvated and enters the umbilical foſſa; from whence about the middle, it immerges and ramifies through the liver. There are ſome inſtance in which the venous branch of the poſterior lobule has been ſent diſtinct from the vena portarum.

DCXCVI. The *vena portarum* is on every ſide ſurrounded with a good deal of cellular ſubſtance, derived to it from the meſentery and ſpleen, denſe, ſhort, and adding ſtrength to the membranes; thoſe with which it is furniſhed being harder than the aorta itſelf. Intermixed with this cellular ſubſtance, are alſo many of the ſmaller veſſels and hepatic nerves, which all come together under the denomination of a *capſula*, which is nothing more than the cellular ſubſtance, and never has truly a ſingle fleſhy fibre. By this the vena portarum is conducted to the liver, and firmly ſuſtained; inſomuch, that the branches, being cut, maintain the round lights of their ſections. But each branch of this veſſel is divided into many others, again divided and ſubdivided, after the manner of arteries, till they at length produce the ſmalleſt capillaries. In this courſe every branch of the vena portarum is accompanied with a ſocial branch of the hepatic artery, creeping upon the ſurface of the vein, and the contiguous hepatic ducts, almoſt in the ſame manner as the bronchial arteries uſually creep along the ramifications of the windpipe in the lungs; while, in the mean time, both the artery and the vein are connected to the branches of the biliary ducts by a thin cellular ſubſtance like a ſpider's web. Some go out of the liver, being divided to the ligaments, and inoſculating with the ſurrounding veins. And the ſum of the branches in the vena portarum is always greater than the trunk; whence the lights of all the branches together greatly exceed that of the trunk (XXXVII.): from whence follows a great friction or reſiſtance (CLXXX and CLXII.), after the ſame manner as we obſerve in the arteries.

DCXCVII. But, ſince the blood is in this manner conveyed through the liver to the branches of the vena portarum, together with the hepatic artery, it muſt of courſe be conveyed back again by ſome other veins: and, therefore, the extreme branches of the vena portarum and hepatic artery inoſculate ultimately into other veins, which are *branches of the cava;* which ariſing from the whole circumference of the liver, run together towards the poſterior gibbous part of the liver into branches and trunks, which at laſt go off into ten or more large veſſels. The leſſer of theſe trunks, and greater number of them, paſs out through the poſterior lobule of the liver, and go to the cava through the ſulcus, that lies on the right ſide of the lobule, often completed into a circle by a ſort of bridge or production of the liver; from whence they aſcend together through the diaphragm towards the left ſide. Two or three trunks, much larger than the former, are inſerted into the ſame cava, cloſe to the diaphram, whoſe veins they often take in by the way. The branches of the vena cava are, in the adult, generally fewer and leſs than thoſe of the vena portarum; which is an argument that the blood moves quicker, becauſe of the leſs friction (CLXX.), and of the very collection of the blood into a leſs light or capacity, by which it is always accelerated when there is a ſufficient compreſſing force (CLXX.) As to any valves at the openings of theſe branches into the cava, I know not of any which deſerve to be regarded. The trunk of the vena cava, paſſing through a foramen of the diaphragm, obtuſely quadrangular, ſurrounded and terminated by mere tendons (CCLXII.), is thereby rendered not eaſily changeable: and having ſurmounted this opening of the diaphragm, it then immediately expands into the right auricle. The ſmaller veins of the liver creeping about its ſurface, are ſent forth from the phrenics, renals, and azygos; or at leaſt there is certainly a communication betwixt theſe and the hepatic veins coming from the portæ.

DCXCVIII. That the blood comes from all parts (DCXCV.) by the vena portarum to the portæ, is proved by a ligature, by which any vein betwixt theſe parts and the ligature ſwells; but the porta itſelf, above the ligature, grows flaccid and empty. But that it afterwards goes through the liver to the cava, appears by anatomical injections, which ſhow open and free anaſtomoſes or communications betwixt the vena portarum and the cava, together with the common nature of the veins going to the cava. Again, the difficult diſtribution or paſſage through the vena portarum, like to that of an artery, together with its remoteneſs from the heart, and the oily or ſluggiſh nature of the blood itſelf, occaſion it to ſtagnate, accumulate, and form ſcirrhous ſwellings in no part oftener than the liver. But this danger is diminiſhed by the motion of the adjacent muſcles, and by the reſpiration; as it is increaſed by inactivity, with ſour and viſcid aliments. But, hitherto, we have been ſpeaking of the adult liver, in which both the umbilical vein and the ductus venoſus are empty and cloſed up, although they continue to cohere with the left branch of the vena portarum.

DCXCIX. The *nerves* of the liver are rather numerous than large; hence, when wounded or inflamed, it is capable of no very great pain. They have a twofold origin[157]. Moſt of them ariſe from the large gangliform plexus, made by the ſplenic branch of the intercoſtal nerve, with the addition of a branch from the poſterior plexus of the eighth pair; they accompany the hepatic artery, and, playing round its trunk, are diſtributed with that and the portal branches throughout the liver. Another faſciculus of nerves uſually enters with the ductus venoſus, and ariſes from the poſterior plexus of the eighth pair, but ſometimes from the great plexus.

DCC. The *lymphatic veſſels* of the liver are numerous, being conſtantly and eaſily to be ſeen about the portæ. They ariſe from the whole concave ſurface of the liver and gall-bladder, and run together into a plexus, ſurrounding the vena portarum, going afterwards to the ſmall conglobate glandules, ſeated before and behind the ſaid vein; from whence they meet together in one large trunk, which is one of the roots of the thoracic duct. Upon the convex part of the liver are deſcribed other lymphatics, whoſe inſertion is not well known; but it is hardly probable that they enter the cava, nor have I been able to find that they lead to the ciſtern of the chyle.

DCCI. The interior fabric of the liver is more obſcure. Through the whole ſubſtance of the liver go bundles of biliary veſſels, of branches of the vena portarum, and of the hepatic artery. Each veſſel has both its proper cellular texture ſurrounding it, and ſimilar ligaments, by which it is tied to its fellow veſſels; and, laſtly, the whole bundle has its cellular texture placed round it. The branches of the vena cava lie on the outſide of the reſt, being leſs accurately received into the ſame bundle. Laſtly, the ultimate ſmall branches of the vena portarum, cava, and hepatic artery, together with the bilious ducts, which we ſhall ſoon deſcribe, are united together by means of the cellular ſubſtance (DCXCVI.), into a ſort of mulberry-like bunches, of an hexagonal ſhape, ſurrounded with a lax cellular texture. In theſe bunches, likewiſe there are mutual anaſtomoſes betwixt the portal branches and hepatic artery, with the roots of the vena cava on one ſide, and the firſt organs of the pori biliarii of the liver on the other ſide; which laſt demonſtrate their inoſculations by anatomical injections, for liquors injected by the vena portarum return again through the porus choledochus.

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[157] My obſervations make out three ſources of hepatic nerves; the anterior, which run to the left lobe, ariſe from the eighth pair alone of the right ſide; the poſterior come from the ganglion and plexus ſemilunaris of either ſide; of which thoſe that ariſe from the right ſide of the plexus are ſtrong and large, and conſtitute the great hepatic plexus, likewiſe called *plexus portarum*.

DCCII. Many eminent anatomiſts have taught that the forementioned bunches are hollow, having arteries and veins ſpread upon their external ſurface, and depoſite the bile into their cavity, after it has been ſecreted from the branches of the vena portarum. For this they allege arguments taken from the comparative anatomy of brutes, whoſe liver is made up of more round and definite bunches; and from thoſe diſeaſes which demonſtrate cells and round tubercles, filled with lymph, chalk, and various kinds of concreted matter. To this they might have added the thick ſluggiſh nature of the bile itſelf, by which it is related to mucus, and the analogy of the follicles of the gall-bladder.

DCCIII. But greater accuracy in anatomy will not allow any follicles into which the ſmall ſecretory veſſels open; for ſuch would intercept the courſe of anatomical injections, and give us the appearance of knots, intermediate betwixt the ſecretory veſſels and the biliary pores, which we have never yet been able to ſee: for the wax flows immediately, without any interruption or effuſion, into a cavity in a continued thread from the vena portarum into the biliary ducts. But, again, a follicular or glandular fabric is not allowable in the liver, from the great length of the biliary ducts. For all follicles depoſite their contents into ſome ſpace immediately adjacent; and are unfit to convey their ſecerned fluid to any length of courſe, as they deſtroy ſo great a part of the velocity received from the arteries. Laſtly, the very common preſſure which we muſt ſuppoſe to be on theſe bunches of kernels would ſo cruſh them, that no aſſiſtance could from thence be brought to promote the motion of the excretory ducts. Concretions and hydatids are formed in the cellular ſubſtance; and, laſtly, the bile, when firſt ſecreted, is ſufficiently fluid.

DCCIV. Again, we are perſuaded that no bile is ſeparated from the hepatic artery, becauſe the peculiar ſtructure of the vena portarum would be uſeleſs if it ſecreted nothing. Its office in ſecretion appears plainly by the continuations of its branches with the biliary ducts, in a manner more evident than that of the artery: but it appears by experiments, alſo, that the biliary ſecretion continues to be carried on after the hepatic artery is tied; add to this the largeneſs of the biliary ducts, in proportion to ſo ſmall an artery, with the peculiar nature of the blood collected in the vena portarum, ſo extremely well fitted for the formation of the bile. For we have already ſeen that it contains oil, which abounds more in the bile than in any other humour of the body; for it takes in the ſaponaceous water of the ſtomach by the abſorbing veins, together with the ſubfetid alkaleſcent vapours of the abdomen, which tranſpire through the whole ſurface of the inteſtines, ſtomach, omentum, liver, ſpleen, and meſentery, which are abſorbed again by the veins, as we know by inconteſtable experiments of anatomy; and, finally, the alkaleſcent ſemiputrid acrimonious humidity from the feces while they continue to thicken in the large inteſtines, which is taken up by the internal hæmorrhoidal veins, from whence that bitterneſs, alkaleſcent and putreſcent diſpoſition of the bile is derived. But in the blood of the he-

hepatic artery, we can find nothing peculiarly fit for the ſecretion of bile, or analogous to its nature.

DCCV. Since, therefore, the vena portarum conveys the blood ready charged with biliary matter, fit to be ſecreted in the leaſt acini (DCCIV.), and from thence there is an open free paſſage, without any intermediate follicles, from the ultimate branches of the vena portarum into the beginning roots of the biliary ducts, and that the humours driven into the vena portarum may eaſily chooſe this paſſage, the bile will be expelled from thence by the force of the blood urging behind, as well as by the auxiliary force of the diaphragm preſſing the liver againſt the reſt of the viſcera in the abdomen when very full (DCLXXXIX,) and again, contracted in exſpiration, it will be forced into the larger branches, and laſtly into two trunks of the larger biliary duct of the liver; which trunks meet together in one upon the vena portarum, in the tranſverſe foſſa of the liver, near the anonymous lobule.

DCCVI. The fabric of this duct is made up by a ſtrong nervous membrane like that of the inteſtines, over which is ſpread an external and internal cellular membrane; and is internally lined with a looſe villous tunic, elegantly reticulated, but aſperated with many ſmall pores and ſinuſes, and continued with that of the inteſtine itſelf. But there is here no muſcular fabric apparent. From experiments it appears to be endowed with a moderate degree of irritability. That it is vaſtly dilatable, is ſhewn from diſeaſes. The ſame ſeem alſo to ſhow that this duct is endowed with a very ſharp ſenſation.

DCCVII. The hepatic duct, thus formed, goes on upon the vena portarum, more to the right than the artery, towards the pancreas; and then deſcending obliquely, covered by ſome part of that gland, it goes to the lower part of the ſecond flexure of the duodenum, and is inſerted backward about ſix inches from the pylorus, through an oblique oblong ſinus made by the pancreatic duct, into which it opens by a narrow orifice.

The ſaid ſinus runs a great way through the ſecond cellular coat of the duodenum obliquely downward; then it perforates the nervous coat, and goes on again obliquely betwixt it and the villous tunic; and, laſtly, it opens into a protuberant long wrinkle of the duodenum. Thus there is almoſt the length of an inch taken up betwixt the firſt inſertion and the egreſs of this duct through the coats of the duodenum, by a ſinus which ſurrounds and receives the ductus choledochus, in ſuch a manner, that when the coats of this inteſtine are diſtended by flatus, or cloſely contracted by a more violent periſtaltic motion, the opening of the duct muſt be conſequently compreſſed or ſhut; but when the duodenum is relaxed and moderately empty, the bile then has a free exit. Any regurgitation from the duodenum is hindered by this obliquity and wrinkling of the duct, eaſily preſſed together, or cloſed and joined with a quick ſucceſſion of freſh bile deſcending perpendicularly from the liver. Nor does wind inflated into the inteſtine find any paſſage into the duct.

DCCVIII. But, in the portæ themſelves, this common duct receives another leſs canal of the ſame kind, which lies for a good way parallel with itſelf from the gall-bladder, making its inſertion in a very acute angle; and this, which is called the cyſtic duct, from its origin, is ſometimes firſt increaſed by another ſmall duct from the hepatic before its common inſertion. This duct is formed by the gall-bladder as a peculiar receptacle for the bile given to moſt animals; but is abſent in ſome, eſpecially thoſe of a ſwifter foot, and perhaps only in ſuch of theſe as are herbivorous [158]: it is placed in an excavation

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[158] Animals are for the moſt part diſpoſed into two claſſes with reſpect to the gall-bladder; ſome have it, and ſome want it; among the former the elephant is comprehended by all. Some perfectly want the gall-bladder, as the horſe, aſs: others have it lying in its proper furrow of the liver, and joined with the liver, as in man: others again have their gall-bladder ſeparate from the liver, as, according to Camper's obſervations, in the eagle, and once obſerved by me in man: and ſome ſhow a true bladder, ſhut up in the coats of the duodenum, as the elephant; which ſtructure I learned from Camper's drawing.

tion of the right lobe of the liver (DCXCII.), to the right ſide of the anonymous lobule, in ſuch a manner, that in infants or children it lies wholly within the edge of the liver, but in adults projects conſiderably beyond, lying upon the inteſtinum colon. Its ſituation is almoſt tranſverſe from the fore to the back parts; its neck aſcends a little upwards.

DCCIX. The figure of the gall-bladder is variable, but in general like that of a pear, terminated in its fore-part by an obtuſe hemiſpherical end, which is impervious, gradually diminiſhing backward; the neck or tip of this truncated cone being inflected upwards againſt itſelf once or twice, and tied together by the cellular ſubſtance belonging to it, makes then another ſmall flexure upward, and begins the cyſtic duct; which from thence goes on towards the left ſide of the hepatic duct. Within this duct there are many protuberant wrinkles, formed by the numerous cellular bridles which tie them together; and theſe wrinkles, conjunctly in the dry gall-bladder, repreſent a kind of ſpiral valve; but being altogether ſoft and alternate in a living perſon, they do not ſtop, only leſſen the courſe of the bile, as we are aſſured from experiments, by preſſing the gall-bladder, and by inflations. Beſides, it is reticulated like the gall-bladder itſelf.

DCCX. The outermoſt coat of the gall-bladder covers only its lower ſide, being the common covering of the liver itſelf ſtretched over the gall-bladder, and confining it to the liver within its proper ſinus. The ſecond coat is the cellular ſubſtance, and of a looſe texture. The third coat has ſometimes ſplendent fibres chiefly longitudinal; but ſome obliquely interſecting each other in various directions. At other times it has none at all; ſo that we may doubt of its muſcular nature, eſpecially as the irritability of the gall-bladder is ſlow and obſcure. Next to theſe come the nervous coat, then the ſecond cellular, and laſt the vilous tunic; which are all found here as in the inteſtines, except that the laſt, in the gall-bladder, as well as in the biliary ducts, is reticulated

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and full of cells[159]. Within the gall-bladder, but more eſpecially about its neck and middle part, we obſerve muciferous pores[160], capable of receiving a horſe-hair; and beſides theſe, the exhaling arteries diſcharge ſome quantity of a watery humour into the cavity of the gall-bladder, as we obſerve in other cavities.

DCCXI. All animals, between their gall bladder and liver, or between the ducts coming from both, have, beſides, ſome peculial openings in the gall-bladder, into which ſome ducts orginating from the liver, or the hepatic biliary duct, diſcharge their contents. In mankind theſe ducts have not been ſhown by any certain experiment, and the gall-bladder is eaſily looſed from the liver, without a drop of bile diſtilling either from it or from the liver. There is alſo a thin water in the bladder as often as the cyſtic duct is obſtructed.

DCCXII. The bile flows both out of the bladder and liver, according to its nature, as long as there is no impediment in its way; ſo that both ducts ſwell when that paſſage is obſtructed, and the cyſtic lies in a ſtraight line with the choledochus. Nor is it credible that all the bile ſhould be diverted into the gall-bladder before it flows into the duodenum. There is not a perpetual obſtacle which hinders the afflux, and peculiarly reſiſts the hepatic bile, and admits the cyſtic; the paſſage into the ductus choledochus is larger and ſtraighter, the ductus cyſticus much leſs than the hepatic, nor is that duct ſo well formed for receiving all the bile; the choledochus being much larger than the cyſtic duct, cannot therefore be made only for the reception of its bile. There are many animals in which the hepatic duct diſcharges its contents into the inteſtine without any communication with the cyſtic. In living animals, even when the cyſtic duct is free, the bile appears to deſcend into the duodenum with a perpetual current. That the quantity is very conſiderable, appears from the magnitude of the ſecretory organ, and the excretory duct, ſo many times larger than the ſalival ones; from diſeaſes, in which four ounces of the cyſtic bile only have flowed out duly through an ulcer of the ſide. But the hepatic bile goes into the bladder, as often as there is any obſtruction in the duodenal ſinus, from flatus or any other cauſe compreſſing the exit of the ductus choledochus. Accordingly, we find it extremely full, whenever the common biliary duct is obſtructed or compreſſed by ſome ſcirrhous tumour, whence the gall-bladder is ſometimes enlarged beyond all belief; and if the cyſtic duct be tied, it ſwells betwixt the ligature and hepatic duct; and in living animals, the hepatic bile viſibly diſtils into the wounded gall-bladder, even to the naked eye. The retrograde angle, or direction of this duct, is not repugnant to ſuch a courſe of the bile: for a very ſlight preſſure urges it from the liver into the gall-bladder; and even wind may be eaſily drove the ſame way, more eſpecially if the duodenum be firſt inflated. Nor does there ſeem to be any ſort of bile ſeparated by the gall-bladder itſelf. Whenever the cyſtic duct is obſtructed by a ſmall ſtone, or a ligature made upon it, we find nothing ſeparated into the gall-bladder more than the exhaling moiſture, and a ſmall quantity of inſipid mu-

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[159] On account of the elegant net-work, which is divided into numerous greater or ſmaller cells, I think the name of *tunica reticularis* ſhould be given to this inner membrane of the gall-bladder. Nothing can be prettier than the preparation I have of this human membrane. The whole interior membrane of the gall-bladder, in the ſame manner as the ductus cyſticus, is wrinkled into alveolæ and membranous cells; ſome of which have a regular cubic figure, others are of an irregular figure, oblong, angular, and round: they likewiſe vary in ſize and capacity; in the middle of the cyſt they are larger; towards the extremity and bottom particularly crowded. That membrane which forms little ridges, is in ſome places more than two lines long, in others ſhorter. If, when all the cells and ridges are deſtroyed, you expand that membrane over an even ſurface, it becomes three or four times greater than the cyſt. An elegant net-work of innumerable veſſels runs upon theſe little ridges.

[160] Upon comparing Camper's drawing of the elephant's cyſt with the trials I made upon man, I am fully perſuaded, that the great number of pores, opening into the inner ſurface of the cyſt, pour out a peculiar liquid, which is neceſſary to the preparation of the cyſtic bile, but of unknown uſe.

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cus ſecreted from the follicles (DCCX.) In many animals, we meet with no appearance of any gall-bladder, when at the ſame time there is a plentiful flux of ſtrong well prepared and ſalutary bile diſcharged into their inteſtines. Again, it does not ſeem probable, that the cyſtic branch of the vena portarum can ſeparate bile into the gall-bladder; for that vein in itſelf is a mere reconductory veſſel: nor can any be ſeparated from the hepatic artery; for it muſt be vaſtly beyond probability, that ſuch a ſtrong bile as that of the gall-bladder ſhould be ſeparated from a milder blood than the more ſoft hepatic bile prepared from the blood which is moſt fit for that purpoſe (DCCIV.)

DCCXII. Laſtly, the bile flows alſo from the gall-bladder to the liver, and at length returns into the blood when its paſſage into the inteſtines is totally intercepted, ſometimes alſo from a cauſe latent in the nerves. This paſſage or abſorption of the bile into the ſyſtem is pernicious, and is the occaſion of jaundice; which, when the offending ſtones or concretions are removed, is cured by the bile's free courſe into the duodenum being reſtored.

DCCXIII. Therefore a portion of the hepatic bile being received into the gall bladder, there ſtagnates, only a little ſhaken by reſpiration; and there, by degrees, exhales its thinner parts, which, as we ſee, filtrate thro' and largely penetrate the adjacent membranes. The remainder, as being a fluid of an oily ſubalkaline nature, digeſting in a warm place, grows ſharp, rancid, more thick, bitter, and of a higher colour: for this is all the difference betwixt the cyſtic and hepatic bile; which laſt we find weaker, leſs bitter, lighter coloured, and of a thinner conſiſtence, while it remains within its proper hepatic ducts. That this difference betwixt them proceeds only from ſtagnation, appears from ſuch animals as have only a larger porus hepaticus, inſtead of a gall-bladder; for here we find the bile, which ſtagnates in the larger hepatic pore, is conſiderably more bitter than that in the ſmaller pores of the liver; as for example, in the elephant. But the gall-bladder gives this particular advantage, that it receives the bile when the ſtomach, being empty, has no call for it, that afterwards it may be able to return it in greater plenty, when we principally want it for the digeſtion of the aliments now flowing in great quantity into the duodenum. This flow of the bile is quicker in proportion through the cyſtic duct, as the ſection of that duct is leſs than the ſection of the gall-bladder.

DCCXIV. The gall-bladder, indeed, hardly touches the ſtomach, but the beginning of the deſcending duodenum. But when the ſtomach is extremely diſtended, and in a very full abdomen, it makes a conſiderable preſſure both upon the liver and duodenum; by which the gall-bladder is urged, and its bile expreſſed. Thus the bile flows through a free paſſage, from the gall-bladder into the common duct, and the duodenum: and this it does more eaſily in perſons lying on their back; in which poſture the gall-bladder is inverted, with its bottom upward. Hence it is that the gall-bladder becomes ſo full and turgid after faſting. The expulſive force of the bile is but little more than that of the preſſure received from the ſtomach and diaphragm; for as to any muſcular force reſiding in the fibres of the proper membrane, which may be thought to contract the gall-bladder, it muſt be very weak and inconſiderable.

DCCXV. The hepatic bile is always bitter, but the cyſtic is more ſo; always viſcid; of a full yellow colour, with a tincture of green; miſcible, by triture, either with water, oil, or vinous ſpirits; coagulable by mineral acid liquors; diſſoluble by alkalies, eſpecially the volatile kinds; and extremely well adapted to diſſolve oily, reſinous, or gummy ſubſtances; quickly putrefying, and by putrefaction ſpontaneouſly degenerating to a muſk-like odour. Its chemical analyſis[161], and experiments of mixture with various ſubſtances demonſtrate, that it contains a large portion of water, and a conſiderable quantity of inflammable oil, which, in ſtones of a gall bladder, appears very evidently. The bile, therefore, is a natural ſoap; but of that ſort which is made from a volatile ſaline lixivium, mixed with oil, and has its water along with it. This, therefore, being intermixed with the aliment, reduced to a pulp, and ſlowly expreſſed from the ſtomach by the periſtaltic force of the duodenum and preſſure of the abdominal muſcles, incorporates them all together; and the acid or aceſcent qualities of the food are in ſome meaſure thus ſubdued, the curd of milk is again diſſolved by it into a liquid, and the whole maſs of aliment inclined more to a putrid alkaleſcent diſpoſition: it diſſolves the oily matters, ſo that they may freely incorporate with the watery parts, and make up an uniform maſs of chyle to enter the lacteals; the ſurrounding mucus in the inteſtines is hereby abſterged and attenuated, and their periſtaltic motion is excited by its acrimony; all which offices are confirmed, by obſerving the contrary effects from a want or defect of the bile. Nor is the hepatic bile ſufficient to excite the neceſſary motion of the inteſtines, if the cyſtic is wanting; both which are of ſo much uſe and importance to the animal, that we find, by experiment, even the ſtrongeſt will periſh in a few days, if the flux of bile to the inteſtines be intercepted, by wounding the gall-bladder.

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[161] The chemical examination, which long ago ought to have been carried on, of all the animal humours, has been begun in this age by the inveſtigation of the bile's properties: For ſince from our theory

DCCXVI. Thus it ſlowly deſcends along with the alimentary maſs; and having ſpent its force, or changed

theory of digeſtion not only good and wholeſome bile is required, but ſo many depravities of this humour occur in diſeaſes which come under medicine, it would be of much importance, we ſee then, to know the conſtituent parts of it; by which means we certainly could preſerve the bile in its wholeſome, and correct it in its vitiated, ſtate. Since the experiments of Pringle, Ramſay, and Schroeder, much has been added on this head by the moſt celebrated perſons; Gaber, an anonymous writer's eſſay upon putrefaction, Cadet, Spielman, ten Haaff, M'Lurg, and others.

its bitterneſs by putrefaction, moſt of it is afterwards excluded together with the feces; but probably ſome of the more ſubtle, watery, and leſs bitter parts, are again taken up by the vena portarum. It returns the leſs into the ſtomach, becauſe of the aſcent of the duodenum, which goes under the ſtomach, with the reſiſtance it meets with from the valvula pylori, and the advancement of the new chyle which the ſtomach adds to the former: in man, however, it frequently enters; and always in birds. The bile is of a ſweet ſoft nature in the fœtus; for in them the feces are not very fetid to ſupply putrid alkaline vapours to the liver, nor are there any oily or fat ſubſtances abſorbed from the inteſtines. As the bile is a viſcid fluid, and thickens by inactivity of body in fat animals, and in us from the ſame cauſes, eſpecially when the blood moves languid from grief; ſo it eaſily coagulates into an hard, ſomewhat reſinous, and often ſtony ſubſtance, inſomuch that ſtones of the gall are much more frequent than thoſe of the urinary bladder, as we are taught by our own experiments. Its uſe is manifeſt, as, being triturated with the aliments, it diſſolves oil, reſiſts acidity, and thus ſtimulates the inteſtines to contraction.

DCCXVII. The uſe of the liver, beſides ſecreting the bile, is manifeſt in the fœtus. It ſeems to tranſmit the blood brought back from the placenta, and to break its force. Even in an adult perſon it has the ſame uſe though leſs manifeſt, namely, to retard the return of the blood coming back from the viſcera appointed for preparing the chyle.

CHAP. XXV.

Of the Small INTESTINES.

DCCXVIII. BY the *ſmall inteſtines*, anatomiſts underſtand one continued almoſt cylindrical tube, but whoſe tranſverſe ſection is nearly oval, the obtuſe end being towards the unconnected ſide of the inteſtine. This tube is continued from the end of the ſtomach, the right orifice of which it embraces (DCXXV.); and, being produced through a long tract, ends by an expanſion into a much larger inteſtine. Anatomiſts have uſually reckoned three ſmall inteſtines, though nature has formed but one. However, the duodenum has generally pretty certain bounds, terminating with its end in that part of the abdomen which is above the tranſverſe meſocolon (DCLIX.) But that ſmall inteſtine which lies below this meſocolon, commonly called the *jejunum*, has no certain mark or boundary to ſeparate it from the lower portion, which is commonly called the *ileum:* although the former, abounding more with valves and blood-veſſels, has, in general, a more florid appearance, and is furniſhed with longer villi internally; and the ileum again, having fewer of thoſe vaſcular ramifications, like little trees, abounds more with a ſort of minute glandules: however, theſe differences inſenſibly diſappear one in another, without affording any certain limits betwixt the two inteſtines; they are great in the extreme terminations, but obſcure in the neighbouring parts.

DCCXIX. The *duodenum* ſeems to be denominated from its length. It is larger, and more lax or open, than the other ſmall inteſtines, more eſpecially in its firſt flexures; which is partly owing to its not being circumſcribed in ſome places with any external membrane, and in other places only for a ſmall compaſs. It is florid and tender, having its fleſhy fibres ſometimes of a conſiderable thickneſs. Its origination begins round the ring-like valve at the mouth of the pylorus; from whence being undulated or inflected, but generally in a tranſverſe courſe, to the right downward and backward in an empty ſtomach, it goes under the gall-bladder, to the neck of which it is contiguous (DCCXIV.) From thence it deſcends obliquely and backwards to the right ſide as far as the lower plate of the meſocolon, where it is perforated by the biliary duct, and in that courſe is intercepted betwixt the upper and lower plate of the meſocolon. From thence at laſt it proceeds tranſverſely, but a little aſcending behind the pancreas and large meſenteric veſſels, and goes on to the left ſide along with the left renal vein, where, going out from the duplicature of the meſocolon, and bending round before and to the right of the ſaid veſſels, it paſſes through a peculiar foramen, in which the meſentery and left part of the tranſverſe meſocolon adhere to the inteſtine itſelf; from thence it deſcends forward, towards the lower part of the abdomen, into which it advances under the denomination of the *jejunum*. The largeneſs of this inteſtine, with its aſcent from the inſertion of the biliary duct, joined with the conſequent fold about the root of the meſentery, cauſe a remora of its contents, by which the bile, pancreatic juice, and alimentary pulp, are here firſt intimately blended together.

DCCXX. The reſt of the ſmall inteſtine, having no certain ſeat or diviſion, is continued by innumerable and uncertain convolutions, not to be deſcribed, ſo as to fill up the lower part of the abdomen and pelvis ſurrounded by the colon on each ſide, and lies between the bladder and uterus below.

DCCXXI. The fabric of the ſmall inteſtine is almoſt the ſame with that of the ſtomach and œſophagus. Its external coat, excepting part of the duodenum, is received from the peritonæum or meſentery, applied on each ſide to the obtuſe end of the oval inteſtine, and ſeparated by the intervening cellular ſubſtance, which is often repleniſhed with fat, but more cloſely embraces or adheres to the muſcular fibres in the unconnected ſide of the inteſtine; where the outer and muſcular coats ſtrictly cohere, without ſhowing any remarkable difference from what we have obſerved of them in the ſtomach. By this external membrane, and by the meſentery (DCLXI), the inteſtines are ſupported with a conſiderable degree of firmneſs, at the ſame time that they are allowed every way a free liberty for motion.

DCCXXII. But the fabric of the *muſcular coat* differs from that of the ſtomach, in the figure of its fibres. The largeſt and moſt conſiderable body of theſe fibres is circular, cloathing the tube on each ſide, reſembling each other both in their parallel diſpoſition and appearance, which is that of imperfect arches or ſegments of circles, cemented one to another, paler than other muſcular fibres, and yet remarkably contractile. The longitudinal fibres are, in the ſmall inteſtines, much fewer in number, ſcattered round their whole extent, interſperſed with the former, and are more eſpecially ſpread upon the looſe or unconnected ſide of the inteſtine.

DCCXXIII. Within the muſcular coat, is ſeated the *ſecond cellular tunic*, of a larger extent here, as it was in the ſtomach; and this being ſpread on all ſides round the nervous coat, which it includes, is, in us, ſeldom repleniſhed with fat. But the *nervous* coat, being like that of the ſtomach, ſerves as an internal foundation or ſupport to the whole inteſtinal tube; being compoſed chiefly of compacted fibres, which, by inflation, may be parted one from another, ſo as to reſemble a weblike or cellular ſubſtance. Next to this, follows the *third cellular* coat, which is almoſt like the ſecond; and then the innermoſt or *villous* coat, which differs, in ſeveral reſpects, from that which we deſcribed in the ſtomach: for firſt it is folded on all ſides into wrinkles that are ſemicircular, the extremities of which correſpond one to another oppoſitely, but uncertain in their proportions; into which wrinkles the nervous coat ſlightly enters, whilſt the reſt of the intermediate ſpace betwixt the folds of the villous tunic is filled up by the third cellular ſtratum. Theſe *plicæ* or folds of the inteſtine begin within one inch of the pylorus, and are moſt numerous in the firſt and middle part of the inteſtines, but gradually grow fewer in number downward. Here each ſmall twig of the artery, which is ſpread in the cellular ſubſtance, upon the convexity of the inteſtine on one ſide, is anſwered by another twig, diſpoſed in the ſame manner, on the oppoſite ſide. The plicæ are, at firſt, confuſed in the duodenum, and afterwards become more conſpicuous as the inteſtine ad-

vances;

vances; but the appearance of acute imperfect circles or valves is given to them by anatomical preparation, in which their natural ſtate is altered. They are indeed ſoft, and eaſily inverted, ſo as to give way, in any direction, to the courſe of the alimentary pulp; upon which, however, their number has ſufficient influence to retard the motion, while, at the ſame time, they enlarge the ſurface of the villous membrane.

DCCXXIV. We come now to the true villous coat, which we call ſo in other parts by analogy. Namely, the whole internal ſurface of the inteſtine and its valves, together with the ſmall cavities interpoſed betwixt them, ſend out on all ſides innumerable ſmall fluctuating fleeces like a piece of velvet, the extremities of which are obtuſely conical productions of the inner coat of the inteſtine, and from the cellular ſubſtance, intercepted between the duplicature, and from the ſmall veſſels and nerves wrapped up in that celluloſity, and likewiſe from the lacteal veſſel which we ſhall afterwards ſpeak of, ſo as very much to reſemble the papillæ of the tongue, only of a ſofter texture.

DCCXXV. The chief ſmall veſſel of each villoſity is an oval veſſel opening by a ſlender duct in the ſurface of the villous coat, often filled with milk, which the neighbouring ſmall veſſels every where ſurround.

DCCXXVI. In the internal ſurface of this villous coat, open an infinite number of pores; ſome *larger*, other ſmaller. The former lead to ſmall conſpicuous ſimple glandules of the mucous kind, ſeated in the ſecond cellular ſtratum, and like to thoſe of the vaſcular follicles ſeated in the mouth and pharynx, which likewiſe open with numerous patulent orifices into the inteſtines. In the duodenum theſe are aſſembled together in ſeveral places, without running together; nor can they always be demonſtrated; but many of them are quite ſolitary or aſunder in the ileum, or often aſſembled only a few together; though, in many places, a conſiderable number of the ſame kind are aſſembled together, into a little army of an elliptical figure. They have every where a villous membrane.

DCCXXVII. Throughout the whole tract of the inteſtines are found *pores* of a *leſs kind* ſurrounding the baſis of the villi, and moſt ample or conſpicuous in the large inteſtines, where they were firſt obſerved; but have been lately diſcovered, by a more careful inquiry, in the ſmall inteſtines likewiſe. Theſe alſo ſeem to depoſite a liquor of the mucous kind.

DCCXXVIII. The *veſſels* of the ſmall inteſtines are very numerous. The common larger trunk belonging to the inteſtine that occupies the ſpace below the meſocolon is called the *meſenteric artery*, being the largeſt of thoſe produced by the aorta above the renal arteries. This, deſcending behind the pancreas to the right ſide of the jejunum, and before the colic branches, ſends out more eſpecially a long trunk to the bottom of the meſentery and termination of the ileum towards the right ſide; as on the left ſide it ſends out numerous branches, the firſt and laſt being ſhorter, the middle ones longeſt. Theſe laſt, ſubdividing into ſmaller, join with thoſe in their neighbourhood in ſhape of convex arches; which again ſend out other branches united in like manner, to the repetition of almoſt the fifth ſeries of arches, until the laſt ſend ſtraight and very numerous branches to the inteſtine; where, forming their laſt convexity, their numerous ſmall branches are detached on each ſide the inteſtine.

DCCXXIX. The diviſion of theſe branches in the inteſtine, is much after the ſame regular manner; ſo that one comes out from the meſentery, through the cellular ſubſtance, on the foreſide of the inteſtine, as the other does, in the like manner, upon the lower ſide; which, having given ſmall branches to the outermoſt and fleſhy coat, come to the ſecond cellular one: there the anterior trunk, running out towards the obtuſe vertex of the inteſtinal ellipſis, is continued ſtraight into the poſterior branch ſimilar to itſelf; and, according to its ſize, gradually ſends off ſmaller ſhrub-like twigs, inoſcuculating with each other, and with their oppoſites, by innumerable circles. From this arterial net-work, ſmaller twigs penetrate from the nervous tunic into the third cellular ſtratum, and are, with that, continued to the ultimate extremities of the villi, where they at laſt open by exhaling orifices, and diſcharge a watery humour into the inteſtine; for this continued courſe is eaſily imitated and ſhown, by injecting water, fiſh-glue, or mercury. But late induſtry has diſcovered, that theſe arterial extremities firſt open into an hollow veſicle; from whence their depoſited juice flows out through one common orifice. For the reſt, the arteries in this part form numerous reticular inoſculations, that, by avoiding all obſtructions, they may be able to ſupply the inteſtines equally on all ſides; and that any obſtructing matter may, upon occaſion, be eaſily removed back from the narrower extremities to the larger arterial trunks.

DCXXX. The laſt trunk of the meſenteric artery inoſculates with the ileo-colic. The duodenum has various arteries. The firſt and uppermoſt from the right hepatic goes round to the convexity of the inflexure of this inteſtine, which it ſupplies in its way to the pancreas, and inoſculates together with the lower or left pancreatico-duodenal artery, which makes a like arch round the curvature of the duodenum into the pancreas; being at laſt inſerted into the lower duodenal arteries, produced by the meſenteric in its paſſage before this inteſtine. As to the ſmall arteries which go from the ſpermatics to the duodenum, and from thoſe of the renal capſule, we deſignedly omit any further notice of them.

DCCXXXI. The meſenteric *veins* meet all together, in the ſame courſe or diſpoſition with the arteries, in the meſenteric trunk of the vena portarum; except the right duodenal vein, which goes immediately into the trunk of the vena portarum itſelf; and except thoſe ſmall veins which run in company with the ſmall arteries (DCCXXX.), and are inſerted into the ſpermatics and lumbals. Nor have I been able to diſcover any other veins of the meſentery ariſing from the cava. It is a property in common to all theſe veins to be without valves, and to make free communications with the arteries. Thoſe veins in the villous coat, which is for the moſt part compoſed of veins, abſorb thin humours from the inteſtine; as appears from the injection of watery liquors, which readily run through the ſame way; and, from analogy, in aged perſons, in whom the meſenteric glands, and conſequently the lacteals that paſs through them, are frequently cloſed up; add to this, that birds have no lacteal veſſels, and the celerity with which watery liquors paſs to the blood and through the kidneys, compared with the ſmallneſs of the thoracic duct, chiefly from thoſe experiments which have confirmed by ocular demonſtration the paſſage of water from the cavity of the inteſtine into the vena portarum.

DCCXXXII. The *nerves*, though ſmall, are numerous, whence the inteſtines receive no little degree of ſenſibility; they ariſe from the middle plexus of the ſplenic nerves, and, embracing the meſenteric artery, play round it in great numbers, wrapped up in a very denſe cellular plate. The duodenum has likewiſe ſmall nerves from the poſterior hepatic plexus of the eighth pair. From this great ſenſibility of the inteſtines it is probable, that the ultimate branches of the nerves penetrate into the third cellular coat.

DCCXXXIII. From the exhaling arteries diſtils a thin watery liquor into the cavity of the inteſtines, like the juice of the ſtomach, not acrid, but ſaltiſh. The quantity of this liquor may be computed from the large extent or ſum of all the excretory orifices, and from the ſection or light of the ſecretory artery, larger than which we ſee no where in the body; add to this, the laxity of the parts perpetually kept warm and moiſt, and the copious diarrhœa or watery diſcharge that often follows the uſe of purgative medicines. But the mucus ariſing from the pores or cells before-mentioned (DCCXXVI. (DCCXXVII.) ſerves to lubricate and defend the internal ſurface of the villous membrane, and to guard the ſenſible nerves from ſtrongly acrid or pungent particles. Hence we ſee, it is more abundant at the beginning of the larger inteſtines, becauſe there the maſs of aliment begins to be more feculent, acrid, and tenacious.

DCCXXXIV. The mixture of this liquor with the pulp-like maſs of the aliment, together with the bile and pancreatic juice, is made by the motion of the ſurrounding muſcles of the abdomen; but this force is quite ſmall, and unfit for moving forward the aliments. But for this purpoſe ſerves eſpecially the periſtaltic motion, which is more particularly ſtrong and evident in the ſmall inteſtines [162]. For any part of the inteſtine, irritated by flatus or any ſharp or rough body, contracts itſelf, even after death, moſt violently in that part where the ſtimulus is applied, in order to free itſelf from the offending or diſtending body, which it expels into the next open part of the lax inteſtine; where, being received, it is again propelled forward, by exciting a like ſtimulus and contraction as before. This contracting motion of the inteſtines is made in various parts of the gut, either ſucceſſively or at the ſame time, wherever the flatus or aliment excite a ſtimulus; and this, without obſerving any certain order. So well fitted, however, are the inteſtines for this motion, that they emulate, and even exceed, the irritability of the heart, or at leaſt are ſcarcely exceeded by it. When they are not irritated, they remain at reſt, as I have often obſerved; and we may ſuppoſe this to be the cauſe why the fat remains in the belly. The air acts chiefly as a ſtimulus to the inteſtines[163], next to it is the aliment, and laſtly the bile.

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[162] The road for our food through the primæ viæ begins in the mouth after deglutition; the meat proceeds through the inteſtinal canal by means of a periſtaltic motion, and at laſt is excreted. The beginning and end of this action, viz. the buſineſs of deglutition and ſome part of the alvine excretion, depends upon the will of the animal: the motion of the œſophagus, ſtomach, and inteſtines, can neither be increaſed nor retarded in any way by our inclination.

[163] To theſe are added in a diſeaſed ſtate external cold, joined with humidity, affecting the abdomen and feet, and evacuants of any kind.

This motion is performed by a wonderful ſort of alternate creeping and revolution of the inteſtines, which diſſection eaſily demonſtrates in living brute animals, and unhappy caſes of wounds in the abdomen and ruptures have manifeſted in the human ſpecies. And ſince here, among ſo many inflexions, the weight of the aliment is but of little force, it eaſily aſcends or deſcends through the irritated inteſtine, which thus empties itſelf. From hence the antiperiſtaltic motion is intelligible, by which the pulp of the alimentary maſs is oftener or longer applied with a gentle force to the triture of the inteſtine, to the exhaling diluent liquor, and to the mouths of the abſorbing veins. But all the contents of the inteſtine are determined downward to the large inteſtines, becauſe the ſtimulus begins above, from the left opening of the ſtomach; and ſo, by the ſucceſſion of new chyle, repeating the ſtimulus above the contraction, it deſcends, when there is no reſiſtance made to it, into the lower part of the ileum, at its opening into the colon: here the looſe part of this inteſtine readily receives what is preſſed into it by the contraction from above, and as eaſily unloads itſelf into the large unactive cæcum; from whence it is again repelled upward, and in part urged on by the preſſure of the ſucceeding maſs. Anatomiſts obſerve, that this motion is made ſtronger downward than upward, and that the ſuperior parts of the inteſtines are more irritable than the lower. But as often as an inſuperable obſtacle reſiſts the paſſage of the aliment, there will be the ſeat of the principal contraction, and the aliment likewiſe is driven upward from the valve of the colon through the whole length of the inteſtines, into the ſtomach, and laſtly into the mouth.

DCCXXXV. This periſtaltic motion of the inteſtines is performed by the conſtriction of their circular fibres, which know how to empty the tube exactly, without injuring the inteſtine againſt pins, needles, or any other ſharp bodies lodged within their contents, which they tenderly promote forward. But the revolutions of the in-

inteſtines, drawn upward and downward, and the ſtraightening of crooked parts of them one before another, which is ſo remarkably conſpicuous in brute animals, are performed by the long fibres, which we ſee contract themſelves at the ſeat of the preſent ſtimulus, and dilate the following portion of them to receive what enſues. By the ſame contraction the villous membrane of the inteſtines, within their cavity, is urged and reduced into longer folds; whence the mucus is expreſſed and applied to that part of the alimentary maſs, where it was required by the force of irritation and ſtimulus. Theſe long fibres frequently make intro-ſuſceptions of the inteſtines, and generally without any bad conſequences, by drawing up the contracted portion of the inteſtine into that which is looſe, in ſuch a manner, that the former is ſurrounded by the latter, which is relaxed.

DCCXXXVI. The alimentary pulp, therefore, diluted with the pancreatic juice and that of the inteſtines, intimately mixed with the ſaponaceous bile and circumjacent mucus, is more perfectly diſſolved than by the efficacy of the ſtomach, in proportion as the ſides of the inteſtines come into a larger contact, and approach nearer together; to which add, the longer ſeries of the periſtaltic motions, and the greater quantity of diſſolving juices. In this manner, the alimentary pulp, intermixed with air, forms a froth, without any kind of fermentation, which air is the ſame with what we commonly eructate from the ſtomach; but yet, at the ſame time, the acid or aceſcent force is ſubdued, while the oily or fat parts, diſſolved by the bile (DCCXV.), intermix with the watery juices, and give the chyle its uſual milky appearance, like an emulſion, of a bright colour in the duodenum, at the firſt entrace of the biliary duct; from whence downward it cloſely adheres to the villous coat of the ſmall inteſtines. But the gelatinous juices of fleſh meats, diluted with a large portion of water, and likewiſe from their own ſubviſcid nature, do more particularly adhere to the villous coat, and enter it in the way of abſorption. So water and watery liquors are all very greedily drank up by the veins: and yet the feculent remains never grow thick in the ſmall inteſtines, as far as I have been able to obſerve, becauſe the watery part is repaired by the arterial vapour and mucus; nor do they become fetid in any conſiderable degree, as well becauſe of the great quantity of diluting juices, as becauſe the quick progreſſion will not allow them time enough for a putrefaction. Thoſe remains, which are of a more earthy, groſs, and acrid diſpoſition, which were excluded by the mouths of the abſorbing lacteal orifices, do, by their weight, or by the muſcular contractions, deſcend ſlowly into the large inteſtines, ſo as to complete their whole courſe in the ſpace of about twenty-four hours. But within three, four, or a few more hours time, all the chyle of the aliment is commonly extracted.

DCCXXXVII. The conſiderable length of the ſmall inteſtine, which is five or more times longer than that of the body, the great ſurface of the villous membrane increaſed by folds, the incredible number of exhaling or abſorbing veſſels, the ſlow courſe of what remains through the large inteſtines, and the great quantity of the inteſtinal juice poured into the alimentary maſs, do all of them concur, in the ſmall inteſtine, abundantly to perform what is required in the emulſions of the food for our healthy juices, and for their abſorption into the lacteals and the meſenteric veins: alſo for abſterſion of viſcidities from the inteſtine; for the avoiding adheſions and coagulations; for the deſtruction of any acid diſpoſition not yet ſubdued; and for the ſubduing any venomous quality in many juices, which, being directly mixed with the blood, inſtantly kill, but are thus ſent in by the mouth without damage. Hence, in general, the inteſtines are long in animals that feed upon any hard diet, but ſhorter in carnivorous ones, and ſhorteſt in all thoſe that live upon juices: and, even in man, an uncommon ſhortneſs of the inteſtines has been known to be attended with hunger, and a flux or diſcharge of fetid and fluid feces.

DCXXXVIII. The heat by which the aliment is fomented, and which is exceedingly proper for the ſolution of the gelatinous matter, and exciting a beginning putrefaction, is hence the principal cauſe of the fetor which is gradually produced in the aliment; thence alſo is the cauſe of that thinneſs by which the uſeful part of the aliment is fitted for abſorption. But the air alſo, incloſed in the viſcid aliment, operates here, as in the ſtomach, by breaking the coheſion of the aliments, if any yet remain whole. The inteſtinal water dilutes the little maſſes of aliment; and if any hard part remains, this liquor ſoftens it by maceration. The bile being intimately mixed with oil, diſſolves the ſame, and renders it miſcible with water.

CHAP. XXVI.

Of the Large INTESTINES.

DCCXXXIX. WHAT remains, after the chyle has been abſtracted, conſiſts of ſome portion of the bile, but mucilaginous and degenerate; ſome part of the human mucilages; moſt of the earthy parts that were lodged in the food; and all thoſe parts which by their acrimony were rejected by the abſorbing mouths of the lacteals, yet changed by means of putrefaction (DCCXXXVI.); with all the ſolid fibres and membranes, whoſe coheſion was too great to be overcome by the maceration and periſtaltic motion in the inteſtines.

DCCXL. All theſe remains paſs from the extremity of the ileum into the cæcum, in which they are collected and ſtagnate; namely, the extremity of the ſmall inteſtine, called the *ileum*, applies itſelf obliquely, in ſuch a manner, to the right ſide of the colon, reſting upon the right ileum and its muſcle, that, in general, it aſcends in a curve, but more in its lower ſide, and leſs in its upper, which is almoſt tranſverſe. But finally, the nervous and villous parts of the ileum are ſo extended betwixt the departing fibres of the muſcular and nervous coat of the colon, as to hang pendulous within the cavity of this large inteſtine, with a double eminent wrinkle or ſoft fold, compoſed of the villous and nervous coat of the thick inteſtine, and of the ſmall inteſtine likewiſe, and of the interpoſed fleſhy fibres of the ileum and colon, joined together by a good deal of the cellular ſubſtance. The upper tranſverſe fold is ſhorter, as the lower is broader and more aſcending; being conjoined by a ſmall production of the ſame kind, more eſpecially in the right ſide, adjacent to them. Betwixt theſe two folds, the mouth of the ileum opens, like a tranſverſe ſlit. But when this inteſtine is inflated, the ſtructure of it changes very much; repreſenting theſe parts to us under the figure of membranes and hard valves. After the cellular plate has been entirely removed from them, the ileum comes clean out from the colon, and the valvular appearance is no more to be ſeen; but if a large part of it only be drawn out, leaving a ſmall portion inſerted behind, it reſembles a ſphincter.

DCCXLI. Below the entrance of the ileum, at the diſtance of ſome inches, the great inteſtine deſcends and forms a blind or impervious extremity, called the *cæcum*; reſting upon the ileum. From the lower part of this, towards the right ſide, extends a ſmall worm-like proceſs, in adults of conſiderable length, like a long extended cone or little inteſtine, variouſly incurvated; ſometimes downward, and full of ſmall mucous glands, which pour out a gluey mucilage to the feces; but, in the fœtus, the colon itſelf is extended into a conical *appendix*. But the weight of the ſuperincumbent feces, depreſſing the ſpace on the right ſide of the appendix, the ſtrength of the cellular texture uniting the left part of the cæcum with the ileum; of the fleſhy fibres uniting both inteſtines; the very contractile force of the ligaments; the fitneſs of the anterior ſac of the cæcum, which eaſily receives the feces from the inteſtinum ileum; all contribute to remove the appendix from the middle, and make it to go out from the left extremity of the colon: and thus is produced the thick and pendulous globe of the colon lying fartheſt to the right ſide, and which is proper to adult perſons. When, therefore, the remains of the alimentary maſs are ſent from the ileum into the colon, they fall by their weight firſt into the cavity of the cæcum, or impervious bag-like appendix: here, by ſtagnating, and the warmth of the parts, they begin to putrefy, according to their particular nature; and here, eſpecially, the fetid ſmell, obſervable in the excrements, begins.

DCCXLII. The *colon* is an inteſtine altogether continuous, as one and the ſame with the cæcum; namely, the largeſt of the great inteſtines, and by much the ſtrongeſt. Beginning upon the ileum (DCCXL.), it aſcends over the right kidney, and lies under the liver, with an angle in the right hypochondrium; being connected to the viſcera, on each ſide, by the peritonæum. From thence it paſſes under the liver and ſtomach, for the moſt part tranſverſely, to the ſpleen, under which it ſtretches (DCLXXVI.), and in the deep receſs under the left ribs is often twiſted upon itſelf. From thence, again, continuing its deſcent to the left ileum, it forms a large flexure (DCLVIII.); from which flexure it is continued, in its lower part, through the pelvis, under the denomination of *rectum*.

DCCXLIII. The ſtructure of the colon is in general the ſame with that of the ſmall inteſtines, but it has ſeveral things peculiarly differing from them. And firſt, all the longitudinal fibres are collected together into three bundles which run through the whole extent of the inteſtine; and of theſe one, and that the largeſt, lies naked; the other ariſes from the omentum; and the third is contained in the meſocolon. Theſe are ſhorter than the inteſtine, and contract it ſo that the nervous and villous membrane (DCCXLIV.) protuberates inwardly. Theſe fibres are connected moſt accurately with the external coat of the inteſtines; but in the intermediate places, and chiefly at the meſocolon, is ſeated the firſt cellular ſtratum repleniſhed with fat. At firſt, being dilated, they adhere to the vermiform appendage. In the extremity of the colon there are often only two ligaments, where the two leſſer join into one. They diffuſe themſelves upon the rectum in ſuch a manner as to occupy the whole.

DCCXLIV. Again, the fleſhy and nervous coat, and third cellular ſtratum, with the villous tunic of the colon, are extended into much larger wrinkles in the parts betwixt the ligaments, often projecting in a threefold rank, ſuſtained by the ligaments, that they may be able to reſiſt and ſupport any ſhock or preſſure from the motion of the feces. In the beginning of the colon, they obſerve their three-fold order, exactly enough, at regular diſtances; but in their progreſs they vary more by degrees, being leſs, ſometimes double, often ſolitary, ſmall and large intermixed, or none at all. Where the ligaments which contract the colon diſappear, theſe valves almoſt diſappear entirely. Laſtly, the villous coat is thinner, without villi, but porous and wrinkled, furniſhed as well with large peculiar pores of its own leading to round folicles or cells which are ſolitary, as with innumerable ſmall pores leading to ſmaller follicles, both which ſupply a great quantity of mucus.

DCCXLV. The *blood-veſſels* of the large inteſtines are partly from the greater and left meſenterics, and partly from the hypogaſtrics. The middle colic artery ariſes from the large meſenteric trunk, as that deſcends behind the tranſverſe meſocolon, where it ariſes up with one, two, and ſometimes three branches, going to the right ſide with the ileo-colic; and to the left, where, with the lower meſenteric, it meets it in a very large arch, which makes the moſt conſiderable arterial inoſculation in the whole body. Again, under the meſocolon, from the ſame large meſenteric artery, ariſes a conſiderable branch that goes directly to the fold of the ileum with the colon, and upward to the right colon with the middle colic; but to the left it runs together with the meſenteric, out of the middle of which it gives a branch that runs along the worm-like appendix of the meſocolon, and terminates itſelf in both the anterior and poſterior fold, by which the ileum is inſerted into the colon. Laſtly, the lower meſenteric, ariſing by its proper trunk from the aorta, betwixt its bifurcation and the renal arteries, goes to the left colon: above, it runs by a large arch, together with the middle colic, and being bent downward in three or four trunks, it ſpreads over the flexure of the colon, and deſcends even into the rectum. Here the rectum receives various branches from the middle hemorrhoidal, ariſing from the laſt trunk of the hypogaſtrics, and conjoined with the former. The ultimate arteries are from the ſame trunk, but diſtributed without the pelvis. We neglect here the ſmaller colics, ariſing from the ſpermatics, intercoſtal, omental, capſulary, and lumbal arteries. The veins, taking the ſame courſe with the arteries, run together into the gaſtrocolic and the internal hemorrhoidal, and hence into the vena portæ; laſtly, they unite with the middle and external hemorrhoidals, and the trunks of the iliacs.

DCCXLVI. The diviſion of the veſſels to the large inteſtines, differs much from that of the ſmall inteſtines. The arches the trunks ſend off, are neither ſo frequent nor ſo often ſubdivided; they run further entire upon the inteſtinal tube, accompanied with fewer glands, and their branches are diſtributed not ſo much like trees; they are divided by leſſer angles, more flexible, and form fewer net-works in the cellular ſubſtance; but they diſtil an exhaling moiſture into the cavity of the inteſtines, as the veins likewiſe abſorb a thin fetid vapour from the feces. The external, and perhaps alſo the internal ones, ſwelling into varices, pour out the hemorrhoidal blood; which is always preternatural, although ſometimes infarctions of the veſſels of the porta are relieved by that evacuation.

DCCXLVII. But there are alſo *lymphatic* veſſels, ariſing from the whole tract of the colon and rectum, which conjoin with thoſe of the loins. We are not without examples of the chyle entering theſe lymphatics from the colon inſtead of lymph; which is an argument that they are of ſome further uſe in this part, by conveying nouriſhment to the blood.

DCCXLVIII. The *nerves* of the large inteſtines are, from the left colic plexus, compoſed by the deſcending branches of each renal plexus, and others ariſing from the intercoſtal trunk of the thorax and loins, with others produced from the large meſenteric plexus. Theſe nerves accompany the lower meſenteric artery, and paſs with them to the colon[164]. The lowermoſt nerves ariſe from the plexus juſt mentioned, and go to the rectum, within the pelvis; others are from the lower intercoſtals, and the nerves of the ſacrum, which terminate likewiſe in the rectum. Theſe nerves are of the ſmaller kind; which renders the inteſtine leſs ſenſible, that it might better ſuſtain the preſſure of the hard and acrid feces.

DCCXLIX. The inteſtinal feces, therefore, retained in the blind beginning of the colon or large inteſtine (DCCLX.), there grow dry by the abſorption of moiſt vapours, ſo as to be capable of receiving a figure from the round contracted parts of the colon; they aſcend from the bottom of the cæcum, elevated by the long ligaments, which end in the worm-like appendix. And here the manner in which the feces are propelled by the contraction of the circular fibres, appears better than in the ſmall ones. The longitudinal fibres of the inteſtine, being attached to the contracted parts as fixed points, draw up and dilate the lower parts of the inteſtine; then the next parts of the inteſtine, to which the feces are brought, being irritated and contracted in like manner, are immediately after drawn together by the round and long fibres; by a ſucceſſive repetition of which the feces finiſh their courſe entirely, through the whole large inteſtine

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[164] An infinite number of nerves, taking their riſe as above mentioned, goes to the great inteſtines; a greater indeed than to the ſmall: They make up a very large plexus upon the meſocolon, with which many filaments are intermixed from the hypogaſtric plexuſes.

teſtine, for the moſt part in 24 hours in a healthy perſon. For wounds in mankind, and the comparative anatomy of brute animals, demonſtrate this periſtaltic motion of the inteſtines to the eye; which is alſo confirmed by the antiperiſtaltic motion, and its conſequences, by which the matter of glyſters is returned up through the mouth. The ſame fibres reſiſt the air contained in the inteſtines; and wind is ſaid to be generated as often as theſe fibres being overcome by its impulſe yield, and the inteſtine is dilated.

DCCL. While the groſs feces aſcend by the folds (DCCXL.) or valves of the ileum, the weight of them depreſſes the lower fold to the left ſide, which draws back the ligament common to each valve, in ſuch a manner as to compreſs and exactly cloſe the upper fold downward, that nothing may return back into the ileum; which might eaſily happen in a fluid ſtate of the feces, if this port was not ſo accurately ſhut up. The feces, when in danger of falling down from the upper parts, depreſs the upper valve, and thus accurately exclude themſelves. This happens very exactly with the feces, but not ſo accurately with water. From thence they continue to move ſlowly forward, more dry, conſiſtent, and figured by the ſame cauſes (DCCXLIX.) through the whole tract and repeated flexures of the colon, which is ſometimes of five or ſeven feet in length, ſo as to retain the feces a ſpace of time ſufficient to give no interruption to the affairs of human life; and this time is proportionably leſs than 24 hours, the greater the velocity with which the ſmall inteſtines propel their contents.

DCCLI. At length the figured excrement falls into the *rectum*, which is inflected firſt a little downwards and then forward, of a broad depreſſed figure, at firſt deſcending contiguous to, and afterwards ſpread under, the bladder, or vagina, but connected more with the former than the latter. Here, for a great while, and often to a great quantity, the feces are collected together,

ther, in a part which is looſe, or openly ſurrounded with ſoft viſcera and muſcles, with a good deal of fat.

DCCLII. The ſtructure of the rectum differs very much from that of the other inteſtines. The external membrane or peritonæum is only ſpread before it; while behind it is ſupported by a broad ſtratum of the cellular ſubſtance, repleniſhed with fat, and many conglobate glandules, connecting this inteſtine all the way to the os ſacrum. The muſcular fibres in this inteſtine are much ſtronger and more numerous, more eſpecially the longitudinal ones, than in the other inteſtines; being compoſed of the three ligaments of the colon, expanded and ſeparated firſt over the anterior face, and then over the whole inteſtine; which they dilate againſt the advancing feces, and draw back the inteſtine after it has excluded them. But the tranſverſe fibres are alſo ſtrong; and the laſt of them are oval, forming a protuberant ring, which is the internal *ſphincter* itſelf, by which the opening of the anus is cloſed.

DCCLIII. Moreover, the villous tunic, extremely full of pores, and of a rough ſurface, full of reticulated polygonous and tender wrinkles, has likewiſe ſome ſinuſes peculiar to itſelf. Namely, that part of the inteſtine which is next to the ſkin or outward opening, forms a white firm circle like a valve, into which deſcend the longitudinal folds, but incurvated and approaching one to another in the circle itſelf. Betwixt thoſe folds, are intercepted ſinuſes, hollow upwards, and of a greater depth towards the lower extremity of the inteſtine. Into the cavity of theſe open the mouths of the large mucous glandules; while the margin of the anus itſelf is defended by ſebaceous glandules, that it might not be excoriated by the harder acrid feces.

DCCLIV. There are alſo proper muſcles which govern the anus. Of theſe the outermoſt is the *ſphincter*, which is broad and fleſhy, conſiſting of two plates of half elliptic fibres, which croſs each other towards the coccyx, and towards the genital parts. And there they are inſerted by fleſhy bundles into a callous cellular fabric deſcending from the coccyx. But forward, they are firmly attached, by denſe portions of the ſame kind, to the ſkin of the perinæum; but by three ſtronger portions in the middle, and two in the ſides, they are inſerted into the bulb of the uretha, whoſe lateral parts they ſurround, betwixt the ſphincter and levator[165]. The fibres, therefore, of the ſphincter, placed betwixt the anterior and poſterior face of the rectum, aſcending in a direct courſe, cloſe the opening of the anus, which they ſurround. With the internal ſphincter, the external one is conjoined by fleſhy portions, that they may co-operate together. The conſtriction of them is not perpetual but voluntary; for the anus ſeems to cloſe itſelf naturally, if the ſmallneſs of its opening be compared with the largeneſs of the inteſtine above, and with the correſponding wrinkle(DCCLIII.), aided by the ſtrength of the tranſverſe fibres of the internal ſphincter, and the incumbent bladder.

DCCLV. But there is another office belonging to the *levators*, which are broad complicated muſcles. They deſcend broadly from betwixt the oppoſite protuberances of the oſſa iſchia, placed under the rectum and bladder; and ſerve to ſuſtain the rectum on each ſide, and prevent it from ſubſiding, or from an unſightly everſion. Moreover, the ſame fibres of the levator, declining broadly from each other, in the nature of a ſphincter, to which they join, ſerve to dilate its orbicular fibres, and opens the anus; but, at the ſame time, they both elevate and ſuſtain the inteſtine from prolapſing downward by the preſſure of the hard feces. They ariſe, as is well known, from the ſpine of the iſchium, os ilium, and ſynchondroſis of the oſſa pubis, terminated by the margin of the great foramen of the pubes, and that part of the iſchium which is above the tubercle. Finally, they meet together in one above the coccyx, into which they are inſerted by numerous fibres.

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[165] The inimitable figures of Camper and Santorinus, done with the greateſt clearneſs, have confirmed the truth of the ſtructure of the muſcles of ſphincters, which Albinus's tables repreſent; ſo that almoſt nothing can be added.

DCCLVI. Therefore, whenever the feces are collected to ſome quantity within the rectum, ſo as to be troubleſome by their weight, irritation, or acrimony, they excite an uneaſineſs through the adjacent viſcera; and are then urged downward, by a voluntary preſſure through the ſtraits of the collapſed inteſtine (DCCLIV.), by the force of the incumbent diaphragm, exciting an effort; which urging downward with great force, the viſcera of the abdomen, which is always full, are determined downward, through the inner rim of the pelvis, ſo as to urge upon the contents of the leſs reſiſting bladder and rectum. When the reſiſtance of the anus is thus overcome, the compreſſing forces of the diaphragm abate, and the feces continue to diſcharge from the body, urged only by the periſtaltic motion itſelf of the inteſtine. After the feces are expelled, the inteſtine is drawn back or up into the body, by its longitudinal fibres; after which, the opening of the anus itſelf is cloſely contracted by the two proper ſphincters, as at firſt.

DCCLVII. Theſe feces in men, and carnivorous animals, are very fetid, almoſt putrid, ſubalkaline, ſoft, and contain much oil intimately mixed with ſalts, which are left both by the aliments, as well as by the bile and other humours of the human body. An acrid and fetid water returns from the feces into the blood; hence, coſtiveneſs in fevers is hurtful, putrefaction being increaſed by the affuſion of the abovementioned matter into the body.

CHAP. XXVII.

Of the Chyliferous VESSELS.

DCCLVIII. THE chyle is a white juice (DCCXXXVI) extracted from the aliments, which is afterwards mixed with the blood. That its principal compoſition is of water and oil, ſeems evident, from the ſweetneſs of its taſte, from the whiteneſs of its colour, from its aceſcent and coagulable nature, and from its lightneſs by which it ſwims on the blood; in all which properties it very much reſembles an emulſion. It is compoſed of a vegetable farina, with animal lymph and oil. It every where retains the properties of the volatile and oily aliments. It changes into milk with very little alteration. But afterwards it becomes more manifeſtly glutinous; ſince the pellucid ſerum it contains, either by exhaling the watery part, or by applying an intenſe heat, coagulates into a kind of jelly.

DCCLIX. That the chyle is abſorbed into the lacteal veſſels, by the adhering villous coat, has been a long time known, by experiments of injecting tinctured liquors, which readily deſcribe the ſame courſe; from the white liquor of the lacteals, let out from blood-veſſels; and from the venous nature of them. But late experiments have taught us this in a much better manner. The chyle is abſorbed by a ſmall opening in the extremity of each of the villi, by the ſame force which is common to all capillary tubes, by which it is taken up into the cavity of the abſorbing duct at the time when the inteſtine is relaxed; but the veſicle, by which the abſorbing duct begins in the inteſtine, being preſſed by the ſucceeding conſtriction of the muſcular fibres in the periſtaltic motion, urges the contents further on into the duct, which begins to appear within the ſecond cellular ſtratum. But there is a two-fold ſtratum of theſe abſorbing veſſels, one anterior, the other poſterior, as we obſerved before of the blood-veſſels (DCCXXIX.). From thence, uniting into a larger canal in the firſt cellular ſtratum, the abſorbed liquor enters into the lacteal veſſel, which, in general, follows the courſe of the arteries[166], and likewiſe accompanies their arches, but conjoined with others ſimilar to it into a very obliquely angled net-work. This kind of veſſels hitherto has been obſerved only in quadrupeds[167]. In the large inteſtine they ariſe without the abovementioned veſicle. Very many ariſe from the firſt part of the ſmall inteſtines under the meſocolon; ſome from the duodenum, and ſome from the large inteſtines themſelves.

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[166] To the very elegant drawings of the lacteals in their courſe through the meſentery, given by Aſellius, Cowper, Bils, Duverney, Cheſelden, Stuart, &c. we ſhould add the new ones of Hewſon and Santorinus.

DCCLX. The lacteal veſſels are furniſhed with valves in the very firſt cellular texture of the inteſtine, like thoſe of the lymphatics, joined together by pairs, of a ſemilunar figure (LVII.), which admit the chyle paſſing from the inteſtines, but prevent its return, and ſuſtain its weight. Through this whole courſe, the chyle is urged on by the periſtaltic motion of the inteſtines, as well as by the contractile force of the veſſels themſelves, which, even after death, is ſtrong enough to propel the chyle; to which add, the conſiderable preſſure of the abdominal muſcles, and other parts, determined by the valves.

DCCLXI. But betwixt the plates of the meſentery, at the diviſions of the veſſels, are found an infinite number of ſmall conglobate glandules, but ſomewhat ſofter and more ſpongy, made of a cellular texture, full of juices, covered with an external membrane, leſs hard than in other parts, and painted with numberleſs ſmall blood-veſſels. Some lacteal veſſels are ſeen to paſs theſe glands: moſt part enter them; and, being divided and ſubdivided through their cellular fabric, compoſe the greateſt part of the gland. And, again, other lacteal veſſels are produced out of every gland; and, being mutually joined among themſelves, go off in little trunks, of which the ultimate and largeſt ones go out from the gland. In the ſame manner the chyle enters other glandules twice, thrice, or four times; nor does any lacteal veſſel arrive at the thoracic duct without meeting ſome of theſe glandules, although it may paſs by ſome without entering them. But that this is the true courſe of the chyle, by which it paſſes from the inteſtines to the meſenteric glands, appears from a ligature, by the veſſel growing turgid betwixt the ſaid ligature and the inteſtine; and from ſcirrhoſities in the glands, by which they are rendered more conſpicuous; and from the nature of the valves themſelves hindering any return back to the inteſtines.

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[167] There is no longer a diſpute, whether the mammalia quadrupedes alone have lacteal veſſels, ſince the induſtrious Mr Hewſon has ſhown them in birds and amphibia; and it is no difficult matter to ſhow them in many others, as dolphins and ſea-calves; and Dr Hunter uſed to render theſe veſſels viſible with very little trouble.

DCCLXII. What alteration the chyle undergoes within the cellular fabric of theſe glands is not yet ſufficiently known; but it appears, in general, that ſome thin liquor diſtils from the arteries in this part, ſerving to dilute the chyle, into which it is poured. For it is obſerved, that after the chyle has ſurmounted all the glands, it appears more watery; and thin liquors, injected through the arteries, paſs out into the cellular fabric of the glands, and mix with the chyle. Laſtly, that kind of cream appears manifeſtly in the glandules of infants.

DCCLXIII. From the laſt glandules, which are collected together in the centre of the meſentery, the lacteal veſſels go out very large, and few, to the number of four, five, or more, which aſcend together with the meſenteric artery, and intermix with the lymphatic plexus, that aſcends from all the lower parts of the body, creeps over the renal vein, and then goes along with that which takes its courſe behind the aorta from the lumbar glandules, and with the hepatics. Here the lymphatics take a variable courſe, but moſt frequently terminate in a veſicle of conſiderable breadth at the ſide of the aorta, betwixt that and the right appendix of the diaphragm: there it uſually appears ſomewhat turgid, two or more inches long; and often aſcends above the diaphragm into the thorax, conical both above and below: it is called the *receptacle of the chyle.* In this the gelatinous lymph of the lower limbs, and of the abdominal viſcera, mixes with the chyle, and dilutes its white colour; thus ſometimes it appears filled with a pellucid or reddiſh humour, but frequently alſo with a white milk. But there are ſome inſtances where there are only two or three ſmall and narrow ducts, inſtead of this receptacle or ciſtern of the chyle. This, however, is moſt frequent, and ſuffers a conſiderable alternate preſſure from the diaphragm and aorta, by which the chyle is moved faſter through it, in proportion as the light of the ciſtern is greater than that of the thoracic duct, into which it empties itſelf. Yet ſometimes, though rarely, this veſicle is ſo ſhort, that it may be compared with an egg; but for tne moſt part it is broadeſt in the middle, and decreaſes conically towards each end.

DCCLXIV. That the chyle comes from the inteſtines into this duct, is ſhown from injections, by which quickſilver has ſometimes been driven from the firſt lacteal veſſels to the thoracic duct; from ligatures made on the duct itſelf, or the red veins which receive it, and by which the firſt and ſecond lacteal veſſels ſwell; and from the manifeſt flux of the chyle into the thoracic duct, when the ligatures are removed.

DCCLXV. The *thoracic duct*, as it is called from its courſe, is generally ſingle; or, if it be double for ſome part of its courſe, it ſoon after unites into one again, which goes behind the pleura, betwixt the vena azygos and the aorta; and, aſcending in an inflected courſe, it receives in its way the lymphatic veſſels of the ſtomach, œſophagus, and lungs, and paſſes through the conglobate glands, of which there are many incumbent on and about it; and theſe lymphatics, as they advance towards the duct, are collected into large bunches. It is, in general, cylindrical; and often forms inſulations, by ſplitting or dividing into two or more; after which it unites into one again, more eſpecially in its upper part. It has few valves, and thoſe not very conſpicuous. About the fifth vertebra of the back, it generally croſſes behind the œſophagus, and then aſcends along the right ſide of the thorax, behind the ſubclavian blood-veſſels till it has arrived near the ſixth vertebra of the neck.

DCCLXVI. There, bending down, it often divides into two, and each deſcending branch dilates into a ſort of veſicle that enters, either with diſtinct or united openings, into the juncture of the ſubclavian and jugular vein internally, by an oblique courſe from the upper, poſterior, and lateral part downward towards the left, and forward, going either with one or with two branches under the ſubclavian, on the outer ſide of that juncture. It has a true almoſt circular fluctuating valve, which by its deſcent keeps out the blood ready to enter. It is rarely otherwiſe diſpoſed; and more rarely ſplit into two, for diſtinct inſertions into the ſubclavian; and yet more rarely apt to ſend off a branch into the vena azygos. Near its inſertion it receives the opening of a large lympatic veſſel, tranſverſely from the arm; and another deſcending from the head, in one or more trunks.

DCCLXVII. It appears that the chyle flows through the thoracic duct into the blood; becauſe, on tying the red veins, both the thoracic duct and lacteal veſſels which are inſerted into it ſwell up.

DCCLXVIII. I have attributed the firſt cauſe of motion in the chyle, and of its abſorption, eſpecially to the attraction of the capillary veſſels, which obſerves alternate pulſes with the periſtaltic contraction of the inteſtine. The attractile force fills the villoſity; the periſtaltic force empties the villoſity, and moves the chyle farther forward. The reſt of its motions ſeem to depend on the ſtrength of the membrane of the lacteal veſſel itſelf, which, even after the death of the animal, expels the chyle, ſo that the veſſels become pellucid, which before were milky. The alternate compreſſing force of the diaphragm alſo is of ſome efficacy in this caſe, and the motion of the chyle through the thorax is ſomewhat accelerated by the conduit itſelf; which being preſſed, moves the chyle ſo much the more quickly forward, as itſelf is larger than the thoracic duct.

DCCLXIX. The chyle, mixed with the blood, does not immediately change its nature; as we learn from the milk, which is afterwards made of it. But after five or more hours have paſſed from the meal, almoſt to the twelfth hour, during all which ſpace a woman will afford milk; after it has circulated near 80,000 times through the body, fomented with heat, and mixed with a variety of animal juices, it is at length ſo changed, that a part of it is depoſited into the cellular ſubſtance, under the denomination of fat; a part of it is again configured into the red-blood globules (CXLVII.); another part, that is of a mucous or gelatinous nature, changes into ſerum; and the watery parts go off, in ſome meaſure, by urine, in ſome meaſure exhaled by perſpiration; while a ſmall part is retained in the habit to dilute the blood. Nor is it any thing uncommon for a pellucid lymphatic liquor to fill the lacteals, in a dying animal, inſtead of chyle; or for ſome of them to appear milky in one part of the meſentery, and limpid or pellucid in another; ſince, as to their fabric and uſe, they alſo agree to anſwer the end of lymphatics. There are not, therefore, two kinds of veſſels from the inteſtines; one to carry the chyle only, and another peculiarly for the conveyance of lymph.

DCCLXX. After the digeſtion has been completed ſome time, the lacteal veſſels abſorb pellucid watery juices from the inteſtines, whence they appear themſelves diaphanous; but the thoracic duct is more eſpecially a lymphatic of the largeſt order, conveying all the lymph of the abdomen, lower extremities, and moſt parts of the body, to the blood (LIII.)

CHAP. XXVIII.

Of the KIDNEYS, BLADDER, and URINE.

DCCXXI. THE chyle, which is taken into the blood, contains a good deal of water; the proportion of which would be too great in the veſſels, ſo as to paſs into the cellular ſubſtance, if it was not expelled again from the body. Therefore a part of this is exhaled through the ſkin (CCCCXXXVI.); and another part, as large, or often larger than the former, is ſtrained through the kidneys, and is expelled out of the body.

DCCLXXII. Theſe *kidneys* are two viſcera [168], placed on each ſide the ſpine of the back, behind the peritonæum, incumbent upon the diaphragm, and upon the pſoas and quadratus muſcles of the loins; but in ſuch a manner, that the right kidney is commonly placed lower and more backward than the left. Before the right kidney is placed the liver upon its upper part, (DCXC), and then the colon covers the reſt of its anterior face; and the left kidney is alſo covered by the ſpleen, ſtomach, part of the pancreas, and the colon. They are tied by reduplications of the peritonæum to the colon, duodenum, liver, and ſpleen. Their figure is externally convex, with a ſemielliptic deficiency in their inner ſide; laterally they are flat or depreſſed, inwardly hollow, unequally divided into one upper or longer and thicker plane, and lower ſlenderer extremity. They are firmly inveſted by a ſtrong external membrane, which is denſe, adheres very cloſely, and does not come from the peritonæum [169]. Betwixt that membrane and the peritonæum of the loins, there is always interpoſed a conſiderable quantity of fat, by which the whole ſurface of the kidney is ſurrounded on all ſides, and a neſt is completed, which the kidney does not totally fill, though anſwering to its ſhape. From the kidney the peritonæum aſcends to the liver, ſpleen, colon, and diaphragm, and prepares as it were ligaments for the kidney.

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[168] I have ſeen two caſes of one kidney only; in one, the kidneys being joined, directed the arch upwards; in another downwards: but in fact I ſaw another ſubject, in which there was only one in one ſide, and in the other no veſtige of veſſels or the viſcus appeared.

[169] A very pretty net-work of blood-veſſels is diſtributed over this coat of the kidneys, coming partly from the renal veſſels, and partly from others.

DCCLXXIII. The *blood-veſſels* of the kidneys are very large, as well the arteries, which together exceed the meſenteric, as the veins. And firſt, the renal *arteries* paſs out from the aorta under that of the meſentery, not always in the ſame manner, yet ſo that the left is commonly ſhorter than the right, and each of them frequently in two, three, or four diſtinct trunks. From thoſe trunks ariſe the renal arteries of the lower ſort, with the adipoſe ones belonging to the fat cortex or capſule of the kidney (DCCLXXII.); and not unfrequently they give origin to the ſpermatics. The fat, rather than the kidney, receives the ſmaller branches from the ſpermatics and arteries of the loins. The arteries are thick, ſo that there is a great quantity of membranes in proportion to their light; they are alſo made of very ſtrong ones, and exceed the ſtrength of the aorta by a third part.

DCCLXXIV. The renal *veins* are very large, more eſpecially the left, and more inconſtant in their courſe than the arteries: for the right is often without a branch, ſhort and concealed; while the left always generates the ſpermatic and capſular vein of the ſame ſide, and almoſt conſtantly receives the laſt branch of the vena ſine pari; and being of a conſiderable breadth, it extends a long way tranſverſely, and produced to the left, before the aorta, with the duodenum incumbent upon it. Both the arteries and veins of the kidneys ariſe from the great trunks laterally, a little deſcending in an obtuſe angle; and divide themſelves into many branches, a little before they enter the kidney. That the paſſage of the blood through the renal arteries into the veins is very expeditious, readily appears from the eaſy courſe that is afforded to water, wax, or even air, injected. The uppermoſt veins of the fat of the kidneys come from the capſular veſſels, the middle from the renal ones, and the lowermoſt from the ſpermatics.

DCCLXXV. There are *lymphatic* veins, conſiderably large, found about the renal blood-veſſels, which give origin to the ciſtern of the chyle (DCCLXIII.), which are ſaid to receive the diſperſed branches that are ſpread under the cellular coat of the kidney, and which are rendered manifeſt by putrefaction, or liquor injected into the renal arteries, or even into the ureter.

DCCLXXVI. The *nerves* of the kidneys are ſmall, but numerous; ariſing from a conſiderable plexus, mixed on each ſide with ganglions which are generated by the branches of the great ſemilunar ganglion, conjoined with others from the intercoſtal trunk, creeping along from the thorax itſelf. They enter the kidney, together with the artery, and ſend off the middle meſenteric (DCCXLVIII.), and likewiſe the ſpermatic nerves. As theſe nerves are ſmall, they afford but a moderate degree of ſenſibility to the kidney.

DCCLXXVII. Upon the top of each kidney is ſeated the *renal capſule;* which in the fœtus is large, even larger than the kidney itſelf, but not afterwards increaſing in the adult: it is glandulous, of the conglomerate kind, divided into lobes, of an oval ſhape in the fœtus, and triangular in the adult; and connected on the right ſide to the liver, ſpleen, pancreas, on both ſides to the diaphragm and kidney; to all which it adheres by as many connecting twigs. From a careful obſervation, it ſeems to be inwardly hollow, ſeparable like a ventricle, of a ſmooth ſurface, and terminating inwardly, as if cut with a razor, full of a liquor of a yellowiſh red colour, and of a fluid conſiſtence, almoſt like blood. The arteries of theſe capſules are many, chiefly of three kinds; the uppermoſt from the phrenics, the middle ones from the aorta, and the lower ones from the renals; but the veins are only a large one on each ſide, that of the right to the cava, and the left to the renal vein of the ſame ſide. The ſaid vein creeps almoſt naked, in branches, through the tender ventricle, in a ſulcus, dividing the capſule, and ſends branches through its internal ſuperficies. The uſes of this gland are as yet unknown; although we are led to believe, from the ſituation, that it is ſubſervient to the kidney, and of greater uſe to the fœtus; ſince it is conſtantly found near the kidneys, and in ſo many different animals. It has no viſible excretory duct, nor does it diſcharge any juice, by viſible pores, into the vein.

DCCLXXVIII. The internal fabric of the kidney is ſimple enough, and ſufficiently known. The blood-veſſels having entered the interval betwixt the upper and lower ſtratum of the kidney, ſpread into its ſubſtance, ſurrounded with a cellular ſheath, and divide into branches which go out between the branches of that which is called the *artery of the pelvis*, by columns interpoſed betwixt the papillæ. From thence, both in the papillæ and among them, making arches, they ſurround the origin of the papillæ, nearer to the circumference; but ſometimes joined by ſmall branches: from whence proceed innumerable little twigs, of which ſome return into the papillæ by the intervals between them and the columns; others tend towards the external ſurface of the kidney, and ſometimes, paſſing through the proper coat of the kidney itſelf, enter into its adipoſe covering, where being changed into minute ſerpentine curls, reflected again towards the trunk of the artery from whence they roſe, they form a boundary to the kidney, and are then gradually ſtretched out and mix themſelves among the uriniferous tubes. But from the cortex, as it were by ſome little flames, are produced bundles of the uriniferous tubes collected in great numbers into threads, of which every one contains very many little tubes. That they are continuous with the arteries, or at leaſt that they receive their branches into them, we know, from experiments which ſhow that water, or even air, paſſes eaſily from the arteries of the kidneys into the ureter; and laſtly from diſeaſes, in which the blood takes the ſame courſe. Between theſe papillæ, and about their origin, are ſituated ſome roundiſh knots, which the lateſt anatomiſts take to be the arterial glands, producing the proper and more narrow urinary ducts. Between theſe ſmall ducts run many arteries parallel to one another. It is probable, that the cortex conſiſts of curved veſſels, which eminent anatomiſts have ſuppoſed to be ſmaller than the red ones.

DCCLXXIX. Thoſe *uriniferous ducts*, gradually converging towards the middle of the kidney, are joined together like rays; and are inſerted in great numbers into one blind duct, ſuch as perfect the reſt of the papillæ; and each of which is terminated in its convex extremity by conſpicuous pores. The number of theſe papillæ is not altogether certain, but there are thirteen or more of them; ſome of which are obſerved to be ſimple, ſome triple, and ſome quadruple. Theſe were in the fœtus ſo diſtinct, that the kidney then appeared to conſiſt of as many diſtinct or ſmaller kidneys, as there are of theſe papillæ, connected together by a looſe cellular membrane; and furniſhed every one with its proper cortex of ſerpentine veſſels, and its compages of ſtraight uriniferous ducts, the baſis of all which is in the circumference of the kidney, and their vertices converge towards the centre. The oppoſite cortices of two of theſe little kidneys make a column, becauſe it ſeparates two papillæ. In adults, the cellular ſubſtance being condenſed, unites the renal portions and their papillæ into one even kidney: however, it again almoſt recovers the condition which it had in the fœtus, if the intervening cellular plates are relaxed by often injecting of water, The kidney is alſo remarkably larger in the fœtus than in the adult.

DCCLXXX. Round the protuberant ſurface of the ſaid papillæ, is extended a looſe membranous covering, in ſuch a manner, diſtinct from the papillæ itſelf, as to form a larger ſpace, like a cylindrical tube or funnel, for receiving the papillæ into its cavity, and ſometimes there are two in the neighbourhood of each other. Two or three of theſe tubes meet together in one; and with others of the ſame kind, they at laſt form by that union three hollow trunks, the upper, middle, and lower, which again unite and open, but without the kidney, into one conical canal, called the *pelvis* [170].

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[170] In almoſt no viſcus are there more frequent luſus naturæ, both as

DCCLXXXI. The blood of the renal artery being leſs fluid, as is generally believed, than that of the brain, and probably ſtored with more water, brought by the ſerpentine circles of the arteries, depoſites great part of its water into thoſe rectilineal tubes of the papillæ; a great portion of which water contains oils and ſalts, intermixed with earthy particles, or ſuch other matters as are thin enough to paſs through with it. But the ſmall diameter of each uriniferous duct itſelf at its origin, and its firm reſiſtance, ſeem to exclude the milk or chyle and the coagulable lymph. Hence, therefore, it is, that the blood paſſes ſo eaſily through the open uriniferous tubes, whenever it is urged with an increaſed celerity; or, by a morbid relaxation, they tranſmit not only the oily parts of the blood, but even the milk and ſalts of the meat and drink. But when the ſtrength of the kidney is reſtored by aſtringent medicines, the urine returns to its natural ſtate. The nerves likewiſe have a power of contracting or relaxing theſe paſſages; and thus we ſee that urine, which in health is of a yellow colour, becomes watery from ſudden grief of mind. A vaſt quantity is prepared; equal to that of perſpiration, and ſometimes even more.

DCCLXXXII. The urine, by fire or putrefaction, ſometimes by diſeaſe, and in ſome animals more eaſily, changes into a volatile alkaline nature, intimately mixed with a fetid oil, partly empyreumatic, yellow, and volatile, and in part very tenacious, to be ſeparated only by the laſt degrees of fire, under the denomination of phoſphorus; a ſubſtance ſhining of itſelf, and taking fire in the air: and laſtly, it abounds more with earth than any other juice of the human body, both of a cretaceous and ſparry nature; the latter coming chiefly from the drink, the former alſo from the ſolid parts of the body themſelves diſſolved and mixed with the blood. But there is alſo a conſiderable proportion of ſea-ſalt reſiding in

freſh

as to their bulk, number of veſſels, pelvis, and ureter, than in the kidneys. I have collected a great catalogue, and Sandifort has remarked many varieties.

freſh urine; from which it is even ſeparable, after a long putrefaction, in the making of phoſphorus; in which proceſs a very great part of the urine is changed into volatile alkali. Nor is the urine wholly deſtitute of a vitriolic acid, or at leaſt one much a-kin to it; both in that taken from men, as well as cattle. There is, again, a ſort of fuſible ſalt ſeparable in the urine, which is cooling, and a-kin to nitre. In fevers, the oily and ſaline parts of the urine are greatly augmented both in bulk and acrimony.

DCCLXXXIII. The *ureter* being a continuation of the pelvis, carries on the urine received from the kidney, by preſſure from the incumbent viſcera, the contraction of the abdominal muſcles with thoſe of the loins, and the force of the circulation urging the blood behind the ſecerned fluid, and laſtly the weight of the urine itſelf. Firſt, the ureter is covered by the peritonæum and cellular membrane; but its muſcular coat is weak, obſcure, if any: it has then a ſecond cellular coat; a firm, white, nervous one; a third cellular one, lined with the innermoſt, which is of a ſmooth membranous fabric, porous and glandular internally, and in general moderately irritable. It is of different diameters in different places, and every where ſwells into veſicles. It deſcends over the pſoas muſcle, croſſes over the great iliac blood-veſſels into the pelvis; goes behind the urinary bladder; and in the conjunction of the deſcending and tranſverſe portions of the bladder, enters obliquely betwixt the muſcular fibres and nervous coat; and ſo again, betwixt the nervous and villous coat, in ſuch a manner that the mouths of the two ureters are in the neighbourhood of each other, and open by an orifice obliquely cut off; but they have no valves, neither at their opening in the bladder, nor in any part of their courſe. From their oblique inſertion into the bladder, a protuberant line is formed, by the greater thickneſs of the nervous coat, which deſcends to the caput gallinaginis.

DCCLXXXIV. That the urine is ſeparated in the kidneys, is ſhown by the very nature of the thing, as it can be drawn out by preſſing on its ſmall canals. That it deſcends by the ureter is ſhown by the ſurpriſing ſwelling of the kidney, and that part of the ureter which is above the ligature, as well as the emptineſs of that part which is below it. In the bladder alſo, as well as in the kidneys and ureters, there is an immenſe ſwelling as often as the bladder cannot receive the urine, or cannot emit it; an obſtacle being generated in either place.

DCCLXXXV. Nor does there ſeem to be any other way for the urine to paſs. For although it is certain, that the ſtomach, like all other membranes, exhales a moiſture through its coats; though it is not improbable, from experiments, that the bladder alſo abſorbs; and although the paſſage of mineral Spaw waters, by urine, be extremely quick; yet it does not thence follow, that there muſt be ways, different from that of the ureters, to convey the water from the food to the bladder. For the bladder is, on all ſides, ſeparated from the cavity of the abdomen by the peritonæum; nor is it very likely, that the vapours, which either go out from the bladder, or which are derived towards it from other parts, can here find open pores through the peritonæum; nor do membranes imbibe much that are already wetted, ſo as to fill their pores with humours. But the urine alſo which is contained in the bladder, diſtends it even to death; nor does it find any paſſage through which it can eſcape into the pelvis; and on the other hand, when the ureters are obſtructed with ſtones, ſo that the bladder receives nothing from them, it is either quite empty, or contains a very acrimonious and thick urine, manifeſtly indicating that the water can find no other way from the pelvis into the bladder. And a careful attention to the manner in which mineral waters are diſcharged by urine, ſufficiently demonſtrates, that there is no ſuch rapidity therein as is commonly imagined; but the ſtimulus of the cold water drank, does, like the external cold applied to the ſkin, cauſe a concuſſion of the bladder and urinary parts, by which they are ſolicited to repeated diſcharges of the old urine which was before in the body, and not immediately of that which was laſt drank. Again, the largeneſs of the renal veſſels demonſtrates, that not much leſs than an eighth part of the blood ſent to the body is received at a time, and conſequently there are above 1000 ounces of blood conveyed through the kidneys in an hour; whence it will appear but a moderate allowance, for 20, or even 50, ounces of water to diſtil from that quantity of blood driven through the kidneys in the ſame time. Finally, it is certain, that both man and brute animals periſh if the ureters are cloſed up by a ligature; we then obſerve alſo, that no urine can be found in the bladder.

DCCLXXXVI. The *urinary bladder* is ſeated in the cavity or bowl of the pelvis, which is an appendix to the abdomen, ſurrounded on all ſides by bones; but laterally, and at the bottom, only incloſed by muſcles; and is always larger in women than in men. It is ſituated, ſo as to cohere with the os pubis by a large portion of cellular ſubſtance, by which it is connected to the peritonæum, from thence backward, and for a ſmall part of its ſurface before; but behind, it is extended to a greater length over the bladder, deſcending almoſt as far as the inſertions of the ureters; from whence it returns back again, either over the rectum or uterus in women. Behind the bladder lies the rectum, the ſeminal veſicles, and proſtate gland, with the levatores ani. In the fœtus, the bladder is very long, and ſomewhat conical, extending itſelf much above the oſſa pubis; but in the adult, it hardly ariſes above thoſe bones, even when inflated, becauſe, in them, the pelvis is much larger and deeper in proportion.

DCCLXXXVII. The figure of the bladder is, in general, oval, flatter before, more convex behind, terminated at bottom by a very obtuſe or flat head, that lies incumbent upon the rectum. Such is the figure of it in an adult man: but, in the fœtus, it is almoſt cylindrical; and, in women who have had many children, ſo much flattened laterally by preſſure, that it reſembles a ſort of triangular cone. This change of the figure of the bladder ſeems to ariſe from the weight of the urine, gradually diſtending more the lower parts of the bladder, which are moſt preſſed; by which means the ſides are drawn together from above, ſo as to render it ſhorter and broader. It is of different magnitudes; ſo that, in diſeaſes, by frequent irritation and contraction, it ſometimes becomes very ſmall.

DCCLXXXVIII. The fabric of the bladder is much like that of all large membranous receptacles. The firſt membrane is cellular; in its forepart lax, and repleniſhed with fat; but backward it is thinner, where it unites with the rectum. In this there is a net-work of veſſels, chiefly of veins. Next to this follows a muſcular coat, very difficult to deſcribe, conſiſting of pale contractile fibres, diſpoſed in various reticulated bundles, not continued one to another, but interrupted with net-like ſpaces, in which the nervous coat lies uncovered. The principal ſtratum of theſe is longitudinal; which, ariſing before from the proſtate, is frequently, though not always, ſo connected to the ſynchondroſis of the oſſa pubis, or the membranes covering it, as ſeemingly to ariſe from thence; thence, aſcending and growing broad, they ſpread towards the conical extremity of the upper ſide of the bladder: here paſſing on, they deſcend over the poſterior ſurface, and grow there conſiderably broader, till at length they are finally terminated in the proſtate; but laterally they go off like the palms of one's hands, and are mixed from the anterior and poſterior planes. Theſe fibres muſt neceſſarily depreſs the bladder, and conſequently propel the urine towards its bottom[171].

DCCLXXXIX. The remaining fibres are very difficultly reduced to any order. They fill the intervals of the former; by ariſing from the proſtate backward and aſcending inflected, they form a ſtratum, partly oblique, and partly tranſverſe, the interior ones more than the others, both in the forward and back part of the bladder.

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[171] The accurate figures of Santorinus, publiſhed ſince Parſonius, are undoubtedly elegant and accurate. But nature obſerves no regular rule in theſe muſcular fibres.

DCCXC. The contractile force of the bladder is gentle, but perpetual; ſo that it contracts from its greateſt dilatation to its very leaſt ſize, without any alternate relaxation, and remains long in its ſtate of greateſt contraction. The urine is the leaſt uneaſy ſtimulus; water injected is more ſo, and a ſtone the moſt of any kind of irritating ſubſtance. When diſtended beyond meaſure, it loſes its powers; ſo that it either cannot expel, or cannot retain, the urine.

DCCXCI. Within the muſcular coat is ſpread the ſecond cellular ſtratum, of a tender elegant fabric, that may be inflated, and ſofter than that obſerved in the inteſtines. Next follows the nervous coat[172], as a continuation of the ſkin, and reſembling the nervous coat of the ſtomach: the inner one is more obſcure; difficultly ſeparable from the nervous one; continuous with the epidermis; and, like it, eaſily ſeparable, having a great deal of mucus, and folded into various wrinkles, without any certain order. In the ſurface of this laſt, the pores of the mucous cryptæ ſometimes appear conſpicuous, but not always without difficulty, pouring out a viſcid ſoft glue. The mucus itſelf is very manifeſt, and is prepared in the greater quantity in proportion to the irritation of the bladder. For this mucus there is the higheſt neceſſity, to diminiſh the ſenſation of the acrimony of the urine.

DCCXCII. The *veſſels* and *nerves* of the bladder are in common with thoſe which go to the genital parts, where we ſhall deſcribe them. Thoſe which come from the epigaſtrics are but ſmall. They form principally a net-work in the firſt or outer cellular ſtratum, and then another in the ſecond ſtratum of the ſame ſubſtance. The arteries exhale through the villous coat, as we learn by experiment from anatomical injections;

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[172] We ſhould renounce the name of Nervous coat, both in the bladder and inteſtines, on account of the falſe idea of the origin and nature which it involves; for it neither ſo acutely feels, nor ariſes from nerves: it is only a compact cellular membrane.

and the veins likewiſe abſorb again, to which is owing the greater conſiſtence and higher colour of the urine by a long retention of it. The lymphatic veſſels in the outer cellular ſtratum, are eaſily demonſtrated; but their origin is from another part, probably from the adjacent rectum.

DCCXCIII. The ſame urinary bladder is of the nature of other membranous ſacs, ſo that it both tranſmits water through the inorganic pores of its membranes, and through the ſame abſorbs the water in which it is immerſed.

DCCXCIV. Into this bladder the urine conſtantly flows, in a continued thread, as we are aſſured, from experience, in morbid and uncommon caſes, in which the extremities of the ureters have appeared to the eye. By ſtaying ſome time in the bladder, and from the abſorption of the more watery part, the urine acquires an higher colour, becomes ſharper and reddiſh-coloured. Nor are we fully acquainted with the cauſe which retains the urine in the bladder. The ſphincter is obſcure; the depreſſion of the bladder ſeems to aſſiſt, as it deſcends convex below its mouth upon the inteſtinum rectum, ſo that at laſt the urine arrives at the entrance of the urethra when any quantity of it is collected. Certain it is, that the urine does not flow ſpontaneouſly even from a dead carcaſe.

DCCXCV. At length, by its bulk and acrimony, irritating the ſenſible fabric of the bladder, it is thence expelled, firſt by the motion of the diaphragm and abdominal muſcles, by which the inteſtines are urged againſt the bladder in a perſon who is erect, whereby the urine makes itſelf a way through a narrow and impeded paſſage; and again, by the periſtaltic motion of the bladder itſelf, ariſing from the contraction of its muſcular fabric (DCCLXXXVIII, et ſeq.)

DCCXCVI. By the urine, beſides the particles of food and water, much matter ſeems to paſs off that is noxious to the human body; eſpecially calcareous earth reſorbed from the bones and ſolid parts, and which would not fail to produce bony cruſts and calculi whereever it was ſtopped; the ſparry or gypſeous earth of fountains; an acrid oil mixed with ſalt, ſo as to aſſume a volatile nature. The urine, by its retention, diſpoſes to the generation of the ſtone and gout: when ſuppreſſed, it produces ſharp fevers; and at laſt flows back to the brain, and overflows and deſtroys it.

DCCXCVII. From the anterior vertex of the obtuſe or greater end of the bladder, not from its bottom, goes out a ſlender canal with a ſmall orifice, as a continuation of the bladder itſelf, under the denomination of the *urethra;* and in this, there is a manifeſt continuation of the cuticle of the internal coat of the bladder, with its ſurrounding cellular ſubſtance, and more eſpecially a ſolid nervous coat, of which it is principally compoſed. It is variable in its diameter and direction; in women, it is ſtraight, tranſverſe, and ſhort. I do not find a valve in its mouth.

DCCXCVIII. This canal of the urethra is firſt ſurrounded, on all ſides, by the proſtate gland; from whence it goes out naked, for a ſmall ſpace, that is immediately continuous below with the incipient bulb of the urethra, which likewiſe ſurrounds it on all ſides above; but the cavernous bodies of the penis chiefly cover it above and laterally, ſo as to form a common groove for its reception, and add ſtrength or firmneſs to this otherwiſe lax tube. It begins wide from the bladder, and contracts itſelf conically in the proſtate; from which, being at liberty, it becomes cylindrical, and enlarges at the firſt acceſſion of the bulb; in the penis it is almoſt cylindrical, and again dilates itſelf a little before its termination.

DCCXCIX. This canal is governed by various muſcles, either proper to itſelf, or belonging to the parts adjacent. And firſt, in women, there are manifeſtly fibres placed round the egreſs of the incipient urethra, which are moſtly tranſverſe, but ſome variouſly decuſſating each other; whoſe office, and ſupport in the vagina, manifeſtly appear; namely, to depreſs the urethra, like the ſphincter, about the opening of which they are diſpoſed, and by this means to cloſe its opening againſt the reſiſting contracted vagina and ſphincter of the anus[173]. In man there are tranſverſe fibres of the ſame kind; but, forming an arch that opens upward, they run into the conjunction of the bladder with the proſtate, covering the longitudinal bundle of fibres and proſtate itſelf, which covering of fibres thus become fit for contracting the orifice of the bladder.

DCCC. The firſt tranſverſe muſcle proceeding from that bunch of the iſchium which ſends forth the erector muſcle of the penis, goes tranſverſely towards the other os iſchium, partly paſſes into it, is partly inſerted into the middle bulb of the urethra, and partly degenerates into the accelerator. It preſſes upon, ſhakes, and draws backward, the bulb of the urethra. The other, produced from a branch of the os iſchium, is inſerted into the iſthmus of the urethra before the bulb, and dilates it.

DCCCI. But likewiſe the levator of the anus ſeems to raiſe the urethra againſt the os pubis, ſo as to cloſe the opening of the bladder into it; and, in ourſelves living, we may perceive the accelerator conſtringed, together with the ſphincter, at the root of the penis, ſo as perfectly to cloſe the opening of the urethra, and preſs back the urine even while it is flowing; whence there is no room to doubt, but this muſcle gives a moderate tightneſs for retaining the urine.

DCCCII. An effort being now made (DCCXCV.) by the preſſure of the diaphragm, the urine runs forth with a greater celerity, in proportion as it comes through a canal ſmaller than the diameter of its large receptacle; and, being once diſcharged, frees the body from uneaſy ſenſation. The laſt drops, which remain in the lower part of the bulb, irritating by their weight, are expelled by the accelerator muſcle; namely, a ſtrong muſcular expanſion, placed round the bulb, whoſe fibres are diſpoſed in the ſhape of a feather, meeting together in the middle of the bottom-part of the bulb, and in their fore-part fixed by two tendons into the cavernous bodies of the penis, and in their back-part connected by three muſcular portions to the ſphincter of the anus, two of which portions may be alſo referred to the levators of the anus. This muſcle, when the ſphincter is firmly ſhut, draws the bulb upward; and, with a conſiderable force, alternately contracts the urethra, ſo as to expel the laſt drops of the urine.

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[173] The new muſcle of Santorinus, the depreſſor of the female urethra, which is produced from one ſide to the other.

DCCCIII. The pyramidal muſcle of the abdomen may be thought to draw the bladder downwards by the rope of umbilical veſſels, and likewiſe to relax it, and fit it for the action of the long muſcular fibres. But this cannot be admitted, ſeeing the muſcle itſelf is often wanting; neither can it bring down the bladder, and very rarely comes to the navel.

DCCCIV. But as the urine is ſharp, and the membrane of the urethra very ſenſible, and becauſe the air will likewiſe enter it; for theſe reaſons nature has ſupplied this canal with a large quantity of mucus. This mucus is generated not only from the ſources in the bladder, but more eſpecially from two conglomerate glandules; one of which is ſeated on each ſide in the angle, betwixt the bulb of the urethra and the cavernous body of the penis; from whence it ſends out a ſlender duct, running for a conſiderable length through the urethra. I am ignorant of any glandule of the iſthmus different from the cellular texture. Morover, the whole urethra is full of mucous ſinuſes, of a cylindrical figure; very many of which deſcend towards the glans, though ſome run in a contrary direction, having ſmall mucous cryptæ placed at their ſides, which depoſite there a fluid mucus, and diſcharge it into the urethra. A larger ſort of theſe mucous cryptæ are diſpoſed along the upper ſide of the urethra, beginning before the bulb, at the origin of the glans. There are others, ſtill ſmaller, mixed with theſe large ones, and placed laterally, and about the urethra. In women theſe mucous ciſterns are numerous and larger, which open into their much ſhorter urethra, more eſpecially at its opening.

DCCCV. The neceſſary cleanlineſs and avocations of human life require the urine collected to be diſcharged only at certain times. But theſe advantages could not be obtained without ſome danger of diſeaſe, from the depoſition of the earthy parts of the urine continually confined and at reſt; ſo that, by repeated additions of the like matter cemented together, a ſtone may be at length formed. But the plenty of mucus, with which the urinary paſſages are commonly defended, is, for the moſt part, a ſufficient guard againſt this diſorder, as we ſee the generality of people are free from the ſtone; unleſs the urine is more than commonly charged with an earthy, tartareous, or chalky matter, increaſed by the uſe of hard water full of ſelenitic matter[174], drinking wine, very viſcid food, inactivity of body, and a retention of the urine beyond the calls of nature; or ſome viſcid body capable of attracting the calculous matter; or finally, a diſorder of the kidneys, which might lay a foundation for the adheſion of the earthy matter.

CHAP. XXIX.

Of the GENITAL PARTS *in* MAN.

DCCCVI. THE veſſels belonging to the genitals conſtantly ariſe near the kidneys, and almoſt in all kinds of animals; by which nature ſeems to have intended a double uſefulneſs in one organ, which might be able to diſcharge the urine and ſemen, and to bear a relation likewiſe to the genital parts, though placed at a conſiderable diſtance, in a ſpace betwixt the tops of the thighs, and ſubſervient to cleanlineſs, modeſty, eaſineſs of birth, and the force of ſtraining in delivery.

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[174] The watere iſſuing from calcareous mountains, ſuch as thoſe of Gottingen, rarely generate calculi; they rather cure them: hence copious tea-drinking, and abſtinence from wines and pure generous liquors, are thought to be the primary guardians againſt the ſtone.

DCCCVII. The ſemen muſculinum is firſt formed in the teſticle; then repoſited in the ſeminal veſicles; afterwards ejected from the penis into the uterus, where it renders the female ovum prolific: and therefore this muſt be the order of our inquiry into theſe particulars. The human *teſticles*, but ſmall in proportion to the bulk of the body, are, in the fœtus, lodged within the abdomen behind the peritonæum; from whence, by degrees, they deſcend into the groins; and are at laſt, in a more advanced age, thruſt down below the groin, perhaps partly by their weight, and partly by the impulſe of the influent blood; yet ſometimes they are obſerved to remain behind in the groin of adults. They deſcend by a paſſage, which in the fœtus is open, cellular, and called the *proceſs*, leading from the cavity of the peritonæum into the ſcrotum; and the ſame paſſage, after the teſticle is tranſmitted, is contracted by a law of nature, and preſerves the teſticle[175].

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[175] The teſticles of man, from his firſt beginning, never appear in the ſcrotum, but are always, about the fourth, fifth, ſixth, or ſeventh month, found either in the lower belly, lying in the neighbourhood of the kidney, or fallen down towards the ring, or remaining in the groin; and at the end of the ſeventh, eighth, and ninth months, they get into the ſcrotum. But in ſome quadrupeds, as the elephant, according to Ariſtotle and Camper, they remain connected with the kidney during the whole courſe of life; and in the hedge-hog alſo, as Dr Hunter has obſerved, they are confined within the abdomen. The teſticles, then, we ſee, in man, ought to change their ſituation in time of pregnancy. While they yet remain near the kindeys, they are ſituated within the cavity of the peritonæum, which they lie near, and which in the ſame manner accompanies the ſpermatic blood-veſſels, and ductus deferens, ſituated without the peritonæum, to the teſticle, as it does veſſels to the cæcum: hitherto the teſticle is covered with no vaginal coat. With the lower part of the teſticle is connected the cellular net-work, leading through the ring towards the groins, called by the illuſtrious Hunter *gubernaculum*, whence they ſuppoſe the teſticle to be directed into the ſcrotum. From the cavity of the peritonæum a canal is formed as far as the ſcrotum, which during the deſcent of the teſticle is ſufficiently large; and when once the teſticle is down, forms a true continuation of the peritonæum, formerly known to Galen, de la Garanne, Camper, Hunter, &c. through which canal of the peritonæum parts of the in-

DCCCVIII. The teſticle is defended by various integuments; of which the firſt and outermoſt is that of the *ſcrotum*, made up of a cloſe cellular ſtratum, repleniſhed with veſſels, and cloſely adhering to the ſkin: which laſt has a kind of elaſtic or contractile motion at the approach of cold and in the act of venery, although without any muſcular fabric; yet it has commonly action enough to wrinkle the ſcrotum, and draw up the teſticles. This cellular coat, commonly called *dartos*, is placed round each of the teſticles ſeparately; by the conjunction of which together in the middle, is formed a kind of ſeptum, which appears more remarkable in a dry preparation; and this ſeptum is often imperfect in its upper part towards the penis.

DCCCIX. Within the dartos is ſpread a looſe cellular ſtratum, without any fat, except in the lower part of the ſcrotum, and may be inflated like the ſame ſubſtance in other parts. Next follows a muſcle, from its office called *cremaſter*[176]; which ariſes from the degenerating fibres of the leſs oblique muſcle of the abdomen, and from the tendon of the external obliquus, called by ſome a *ligament*, and ſometimes from other *fibres*, deſcending from the os pubis, and at length backward into a vagina, and, being ſpread every way, ſurrounding the teſticle, ſerves to compreſs, and to elevate it towards it contents.

DCCCX. Next to this follows the ſecond cellular ſtratum, whoſe ſpongy fabric is continued with the outtermoſt, that lies round the peritonæum; and this

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inteſtines and omentum may eſcape together, and join with the albuginea teſtis, unleſs this has already happened in the abdomen: hence the noted herniæ, not quite properly called *congenitæ*, ariſe. In general the abdominal aperture of this canal is ſhut after the deſcent of the teſticles: but it often remains quite open, or ſhut up with ſo ſoft a cellular texture as to yield to the omentum and inteſtines, when grown too fat, and in this way to produce hernias.

[176] You will find it moſt elegantly drawn in Camper's very uſeful plates of herniæ.

ſecond ſtratum is called *tunica vaginalis*[177]. In this the veſicles or cells of its fabric appear larger than elſewhere, and may be inflated one after another. At the beginning of the teſticle, above the epididymis, it is, in a manner, ſo ſeparated from the reſt above the teſticle, towards the rings of the abdominal muſcles, that the inflation can hardly be continued through. Betwixt this laſt membrane and the following is a ſpace, into which are exhaled thin vapours, and ſometimes a water is collected. The inner coat, called *albuginea*, is a ſtrong, white, compact membrane, which immediately inveſts and confines the proper ſubſtance of the teſticle itſelf.

DCCCXI. The teſticle more properly ſo called, is of an oval figure, with an acute vertex, looking upwards and a little outwards. The *epididymis* is a kind of additament to the teſticle; and is a flat ſubſtance, reſembling thick tape, which goes round the poſterior margin of the teſticle, to which it is connected by the cellular texture, and by blood-veſſels. In the lower part it is plain; on the upper part it adheres to the teſticle by a thick and convex head, as it does alſo on the lower part. In the middle, it is partly attached by its baſis, and being partly free makes a blind ſac.

DCCCXII. To the teſticle the *ſpermatic* arteries deſcend, one on each ſide ſent off by the aorta below the renal arteries; but not unfrequently from the renal arteries themſelves, from thoſe of the capſules, or from the aorta itſelf above the emulgents. This artery, the ſmalleſt in the body in proportion to its length, deſcends a long way outward before the pſoas muſcle, and gives ſmall branches to the fat of the kidney, to the ureter, meſocolon, glandules of the loins, and to the peritonæum; but more eſpecially towards the bottom of the kidney, it gives a remarkable branch inflected and covered with fat, yet leſſening itſelf, that takes a ſerpentine courſe behind the peritonæum, as far as the ring of the abdomen. This ring is formed entirely of the tendinous fibres, deſcending from the external oblique muſcle, interrupted in their oblique deſcent by a long aperture, growing wider downward; from this aperture part of the ſmaller inner fibres are broadly detached to the os pubis, and others croſſing cohere with the fibres beloning to the other ſide of the muſcle, which, being collected together, is called the *inner column.* Other ſtronger external fibres, diſtinguiſhed from the former by the aperture, are broadly inſerted by a thick bundle into the outer ſide of the os pubis, under the denomination of the *external column;* from whence various fibres run off to the faſcia lata and groin. The upper part of this opening is in ſome meaſure cloſed up by fibres, ariſing from the outer column, and aſcending in a curve direction round the inner and weaker column. Below theſe fibres there is a ſmall opening left, often ſeparated by tendinous fibres, thro' which deſcends the ſpermatic artery, with the vein, and vas deferens, with a good deal of cellular ſubſtance, by which they are wrapt together into a cylindrical cord; before the external column, through no perforation of the peritonæum, which it has every where lying on this fore part of it. At the baſis of this ring, the *ductus deferens* is joined with the rope of veſſels, and the whole bundle arrives at the groin, and thence at the ſcrotum. The ſpermatic artery gives many ſmall branches to the cremaſter, to the cellular coat, and to the ſeptum of the ſcrotum; and then deſcends in a double plexus, to the teſticle; of which the principal comes from betwixt the epididymis and origin of the vas deferens, at the middle and lower part of teſticle, and then goes, by tranſverſe branches, through the albuginea: the other plexus, that accompanies the vas deferens in the upper part of the teſticle, has a like termination, and is variouſly inoſculated with the former. There are other ſmall arteries, which go to the coverings of the teſticle from the epigaſtrics, and others from thoſe of the bladder, which follow the courſe of the vas deferens, both which communicate with the ſpermatic veſſels.

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[177] There are three coverings which ſurround the ſpermatic cord with the teſticle, known by the name of *vaginal tunics*. The common vaginal, which is the true continuation of the peritonæum; the proper vaginal coat of the cord, conſiſting of a looſer cellular membrane; and the proper vaginal coat of the teſticle.

DCCCXIII. Many of the ſmall arteries play about the epididymis; but the larger of them ſpread tranſverſely through the albuginea, which they perforate in ſeveral places, to enter the innermoſt fabric of the teſticle, through which they are minutely ramified in all points, and ſeparated by numberleſs membranous partitions. There is no large anaſtomoſis or communication betwixt the ſpermatic artery and vein here, any more than in other parts of the body; but ſome red blood is received into thoſe branches that paſs through the albuginea to the innermoſt ſubſtance of the teſticle. But from the long courſe of this artery, the ſmallneſs of its diameter, the number of ſerpentine flexures, the great ratio of the dividing branches to their trunk, and the coldneſs of their ſubcutaneous diſtribution, demonſtrate, that the blood flows not only in a ſmall quantity, but very ſlowly, to the teſticle.

DCCCIV. The *ſpermatic vein* of the right ſide is inſerted into the cava; but that of the left pours its blood into the emulgent vein, or into both; it is enormouſly larger than the artery, and takes the ſame courſe in company with that; but both its trunk and branches are much larger and more numerous, very ſerpentine, and formed into a bunchy plexus of conſiderable length, which is interwove with the artery, and continued as low as the teſticle, there by degrees dividing into two like the artery. There are ſome valves in this vein, but few.

DCCCXV. Theſe external coverings of the teſticle have ſmall arteries from the epigaſtrics; the ſcrotum from the crural arteries, with an internal branch, which are called the *external pudenda;* the fellow veins go to the ſaphena, and to the crural trunk.

DCCCXVI. The *nerves* of the teſticle are many, whence it has a peculiar tenderneſs of ſenſation; inſomuch that faintings and convulſions follow from bruiſing or injuring the teſticle, and particularly a conſtriction of the jaws. Some of them ariſe deep from the renal plexus, from the meſenteric plexus, from the trunk of the intercoſtal nerve, and laſtly from the meſocolic plexus, and follow the courſe of the ſpermatic veſſels. Others are proper to the ſurface of the coverings of the teſticle, from the ſecond, third, and fourth pair of the nerves of the loins.

DCCCXVII. I have frequently obſerved *lymphatic* veſſels in the ſpermatic cord, which are judged to ariſe from the teſticle itſelf, and mix themſelves with thoſe that accompany the inguinal blood-veſſels. The induſtry of late anatomiſts have traced them even to the net-work of the teſticle itſelf.

DCCCXVIII. The blood, moved ſlowly and in a ſmall quantity through the ſpermatic artery, by which it is brought to the inner fabric of the teſticle (DCCCXIII.), is there drained into very ſmall veſſels, which carry their fluids to the *ſeminal veſſels*, although we are ignorant of the manner by which the arteries communicate with theſe canals, the bundles of which form the whole ſubſtance of the teſticle. Theſe ſeminiferous veſſels are exceeding ſmall, ſerpentine, firm, or ſolid, and have a very ſmall light in proportion to their membranes; they are not, however, blind, as I have ſeveral times filled them through the vas deferens. They are collected together into bundles, about twenty in number, divided by diſtinct cells or partitions, which deſcend from the albuginea to conduct the arteries and veins. In each of theſe cells there is a ſeminiferous duct, to convey the ſecreted humour from the ſeminiferous vaſcules. Twenty or more of theſe ducts form a *net-work*, adhering to the ſurface of the albuginea, and forming inoſculations one with another; and quickſilver is very eaſily poured from them into the ſurrounding cellular texture. From that net in the upper part of the epididymis, aſcend twenty or thirty ducts, which, being contorted into folds, form as many *vaſcular cones*, that are joined together by an intermediate cellular ſubſtance; and lying incumbent one upon another, then form the head of the epididymis, and in that head ſoon meet together into one duct without the teſticle[178].

DCCCXIX. This duct being intricately wove by an infinite number of folds and ſerpentine flexures, after a manner not imitated in any other part of the body, and connected together by a great number of looſe cellular ſtrata, is afterwards collected by a membrane of the albuginea into one bundle, called the *epididymis*. But the duct of which it is compoſed, grows larger as it deſcends, being largeſt at the bottom of the teſticle; from whence again aſcending along the poſterior face of the teſticle, in a direction contrary to itſelf, it by degrees ſpreads its ſpiral convolutions, and comes out much larger, under the denomination of *ductus deferens*. Almoſt always, however, a ſmall veſſel ſeparates ſomewhere from the ductus deferens, and aſcends along with the cord, having an uncertain termination.

DCCCXX. This is the courſe deſcribed by the ſemen, propelled forward by the motion of the ſuceeding juices in the teſticle; and perhaps, in ſome meaſure, though ſlowly, by the contraction of the cremaſter: as we may reaſonably ſuppoſe, from the numberleſs ſpires and convolutions formed by the epididymis, obructing almoſt every kind of injection; and, as we may conclude, from the length of time that is required to fill the ſeminal veſicles again, after they have been once exhauſted.

DCCCXXI. The cylindric ductus deferens being made of a very thick ſpongy ſubſtance, included betwixt two firm membranes, bored through with a very ſmall tube, aſcends in company with the cord of the ſpermatic veſſels, and together with them paſſes through the ring of the abdomen (DCCCXII.): thence it deſcends into the pelvis; and applying itſelf to the bladder betwixt the ureters, it ſoon after meets the ſubjacent receptacles, called the right and left *veſiculæ ſeminales*. Here it goes along the inner ſide of the veſicle, as far as the proſtate glandule; and dilating in its paſſage, forms a ſerpentine flexure, that begins itſelf to put on a cellular appearance. But very near the proſtate, being continued from theſe cellular bendings, with a conical duct coming out from the veſicle; it unites in a very acute angle, which does at the ſame time itſelf form a conical duct; which being continued rather with the vas deferens, and ſinking through the proſtate gland, is there wrinkled into a large fold, and going off outward at right angles from its companion on the other ſide, and afterwards ſtraitened, it opens into the urethra, thro' a little hollow protuberance, which has a long tail or deſcent, and is laterally perforated with two very ſmall openings, one on each ſide. By injecting a liquor into the ductus deferens of a dead ſubject, we perceive that it flows both into the urethra and into the ſeminal veſicle, but more readily into the former: but in a living perſon the ſemen never flows out but in the act of venery; and conſequently the ductus deferens conveys all its ſemen, without further delay, over a retrograde angle, to the *ſeminal veſicles*.

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[178] This every obſervation confirms: but I have often ſeen the number of the cones greater. Fontana ſays they have been as many as thirty-ſeven; and the celebrated Monro long ago demonſtrated, that they vary differently in different perſons.

DCCCXXII. By this laſt denomination we call a ſort of ſtrong convoluted inteſtine-like membrane, placed under the baſis of the bladder, connected towards its neck by a good deal of cellular ſubſtance: from this ten or more blind gut-like cells or inteſtinuli go off laterally, in ſome meaſure ramified and divided, but ending in impervious conical extremities. This kind of inteſtine, intermixed with a great deal of firm cellular ſubſtance and ſmall veſſels, is ſo contracted, as to lie within a ſhort ſerpentine heap. For the reſt of its fabric, it ſeems to have externally a pulpy and thick membrane, and likewiſe ſomething ſimilar to the ductus deferens. Internally it is wrinkled, having a ſort of villous ap-

appearance; and is beſides ſaid to have ſmall pores and glandules, with which I am unacquainted, but various and hollow cells it certainly has.

DCCCXXIII. The liquor depoſited into this reſervoir, is in the teſticle yellowiſh, thin, and watery: and the ſame nature it retains in the veſicle, only becomes there ſomewhat thicker and higher coloured; and laſtly, it is white in mankind, when it has mixed with the liquor of the proſtate. It has a ſort of heavy or ſtrong ſmell, of a peculiar kind in each claſs of animals; and it is the heavieſt humour in the human body. In water, however, a part goes off into a kind of cuticle, like a cobweb, that ſwims in the liquid; the greater part, which is ſeemingly of a pulpy nature, falls to the bottom. In the ſemen which is long kept by chaſte people, ſhining globules mixed with the white liquor are eaſily to be ſeen. It has a very great quantity of mucus.

DCCCXXIV. Without the conveyance of this into the womb, no claſs of animals, of which there are two ſexes, can be fecundated ſo as to propagate their ſpecies. The reaſon of this was concealed from us, till the microſcope taught, that in man, as well as in all other male animals, the ſeminal liquor is full of living animalcules, reſembling eels, only with a thicker head; and that theſe are always preſent in healthy ſemen, from the time that a perſon comes of age; but, before that time, and in thoſe who are ſterile from a gonorrhæa, they are abſent[179]. That they are animacules, appears evidently from their various motions, reſtings, and geſtures of body.

DCCCXXV. It has been much doubted what could be the uſe of theſe animalcules; and in another place we ſhall conſider the diſpute concerning the opinion that they are as it were the firſt appearance of the future animal. To me, in the mean time, the nature of the ſeminal animalcules ſeems to be the ſame with that of the eels in vinegar or paſte.

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[179] A very few authors excepted, all agree, that there are animalcula in the ſemen of the more perfect animals; as has been ſhown by the elegant obſervations of Ham, Leuenhoeck, Hartzoeker, more than theſe hundred years; which, alſo the labours of the famous Lieberkuhn, Leidermulier, Burgrav, Gleuhen, and Spallanzani, have confirmed, and demonſtrated all their attributes.

DCCCXXVI. That the ſemen is produced from the lymph of the blood, and that the chyle is added to the lymph, will appear probable from the ſudden alacrity to venery that happens after eating, and which is leſſened by faſting. It is compounded of the liquor of the teſticles and ſeminal veſſels, the former indeed being more evident in ſome animals, and the coagulable milk of the proſtate gland. That liquor, however, only fecundates which is generated in the teſticles; as we ſee from geldings, which, though they have the ſeminal veſſels and proſtate, are yet barren.

DCCCXXVII. The ſeminal fluid is retained in the veſicles as long as a man neither exerciſes venery, nor ſports in imaginary dreams. But it is always a ſtimulus to the animal appetite of venery, as long as it is there preſent in any quantity. But beſides this, there is a conſiderable ſtrong, volatile, and odorous part of the ſemen abſorbed again into the blood, where it produces wonderful changes as ſoon as it begins to be formed; ſuch as the protruſion of the beard, the covering of the pubes, a change of the voice and paſſions, horns in cattle, &c. for theſe changes in the animal are not the conſequences of age, but of the ſeminal fluid, and are always abſent in eunuchs. The growth and ſtrength of caſtrated animals are conſtantly diminiſhed; and in like manner the fierceneſs of their temper, and the ſtrong ſmell of their whole body, are remarkably weakened. And from the examples of ſome animals, and even of mankind, it appears, that the irritation of this fluid has occaſioned death, by exciting convulſions. A retention of the ſemen may follow from a narrowneſs of the excretory duct, a ſcirrhoſity of the proſtate, and other cauſes not ſufficiently known.

DCCCXXVIII. The quantity of ſemen expelled at one time from the human veſicles is but ſmall, more eſpecially in a man who has not long abſtained from venery;

nery; and it is natural to think that the liquor can be but ſlowly produced from ſo ſmall a ſubcutaneous artery. Its generation is accelerated by love, by the preſence of the beloved woman; ſo that it diſtends its veſſels with a ſenſe of pain. Nature herſelf, therefore, enjoins venery, both for preſerving the human race, and likewiſe the health of every ſound man. That it comes from the teſticle, is ſhown by diſeaſes, in which the ductus deferens being obſtructed, a ſwelling of the teſticle has enſued. The veſicles never are emulged, except by venereal actions and appetites.

DCCCXXIX. Seeing the ſemen is in ſmall quantity, that it might be projected with a greater force, and to a farther diſtance, nature has joined another humour, which is generated by the *proſtate.* This is a gland, ſhaped like a heart, with the ſmall end foremoſt, ſo as to ſurround the organ of the urethra, but moſt round its upper ſide. This is one of the hardeſt and moſt compact glands, of a peculiar fabric, yet not evidently conglomerate; it prepares a thick, white, ſoft, or cream-like liquor in a large quantity, which is poured out at the ſame time and from the ſame cauſes (DCCCXL.) with the ſemen itſelf, into a little valley or channel at each ſide of the openings of the ſeminal veſicles, where, mixing with the ſeminal fluid, it imparts the white colour and viſcidity which the ſemen poſſeſſes.

DCCCXXX. But it was neceſſary for this canal of the urethra to be firm and capable of a direct figure, that it might be able to throw the ſemen with ſome ſtrength into the diſtant womb; and therefore a three-fold cavernous body ſurrounds it. The firſt and proper cavernous body of the urethra begins, as ſoon as that canal has paſſed the proſtate, with a thick origin, almoſt like a heart, firſt under the urethra, and then above it, but thinner; from thence it ſurrounds the whole canal, through the whole length of the penis, till the lower part terminates in the glans, while the upper part is reflected from the extremity of the urethra, and, being dilated, returns in a direction contrary to that of the penis, which being circumſcribed by a broad circumference, gradually extenuated, and ſomewhat round, terminates the extremities of the cavernous bodies, upon which it is incumbent, and with thoſe for the moſt part communicates by an imperfect ſeptum. The fabric of this body is cellular, but of a larger ſort than the cells of the cavernous bodies, being compoſed rather of plates than fibres, interwoven like a net, and intercepted betwixt two firm membranes.

DCCCXXXI. Into this cavernous body of the urethra, the blood is poured out from the arteries, which come from deep branches ſent off from the external hæmorrhoidals (DCCCXXXVI.); the truth of which is demonſtrated by the injection of any kind of fluid, which, being urged into the ſaid arteries, eaſily flows into theſe cellular ſpaces ſurrounding the urethra. But theſe are not naturally turgid with blood, becauſe there are veins open and numerous enough in proportion to drink up and return what is poured in by the arteries; but if the return is impeded by compreſſing thoſe veins from the powers hereafter mentioned (DCCCXXXIX.), the blood is then retained within the cellular ſpaces, while the arteries continue to import it more ſwiftly and ſtrongly than the veins return it. Thus the ſtagnant blood diſtends the bulb of the urethra, together with its cavernous body, and the glans itſelf. But this is performed generally at the ſame time, when the other cavernous bodies of the penis, with which this of the urethra has no communication, are likewiſe rigidly diſtended.

DCCCXXXII. But the cavernous bodies of the penis ariſe from the oſſa iſchii and pubis, where they are conjoined by a white, cellular, very denſe, and firm ſubſtance; from whence inclining inward towards each other, they take betwixt them the urethra, a little before its bulb, where, changing their direction, they go on parallel, conjoined together, and with the urethra extended forward along their middle, and terminate with an obtuſe end in the glans, and laterally they are comprehended by the cavernous body of the urethra. Theſe bodies are covered with a very firm integument, and their internal fleſh is ſpungy, like that of the urethra (DCCCXXX.), like which it is capable of being diſtended by the reception of the blood. Betwixt both cavernous ſacs there is a middle ſeptum or partition, compoſed of firm parallel tendinous fibres, growing narrower downward; but not continuous one to another, that the intermediate ſpaces might be larger and more numerous as they are more forward, and that they might leave a free communication betwixt the right and left ſpungy body. Other ſuch robuſt fibres run through the cavernous bodies, and are very firmly inſerted into the ſides of their membranous ſac, ſo as to prevent an aneuriſm or over-diſtention of the penis.

DCCCXXXIII. Theſe cavernous bodies are ſurrounded with a good deal of very tender cellular ſubſtance; of which that ſide lying next the cavernous bodies is denſe and firm, like a membrane; but from thence outward, towards the ſkin, its fabric is cellular and very tender, without including any fat, and continuous with the cellular membrane of the ſcrotum, but always the more tender the nearer the ſkin it is; and, by blowing air into it, it appears to have a fine ſilky texture. But the glans (DCCCXXX.) is naturally covered in ſuch a manner, that the ſkin is continued from the penis, and folded back againſt itſelf, as we obſerve in the eye-lids; both folds of the ſkin being covered with its proper cuticle, and ſtuffed, each with its proper cellular ſtratum, under the name of *preputium*, or prepuce; which may be, like a cap, drawn back from, and again brought over, the glans; at which it changes into a tender papillary body, vehemently ſenſible, covered with its proper cuticle and cellular ſubſtance, ſpread over the reflected cavernous body of the urethra (DCCCXXX.); and, finally, is continued with the membrane of the urethra itſelf. The ſaid prepuce is tied by a double triangular ligament, by which the common ſkin is conjoined to that which makes the covering of the glans. Upon the excavation that ſurrounds the crown of the glans, as well as upon the crown itſelf, are ſeated ſimple ſebaceous follicles, which ſeparate a liniment of a peculiar, ſomewhat fetid ſmell, from the nature of their ſeat, ſerving to abate the attrition of the ſkin, as in other parts of the body. Finally, the whole body of the penis is ſuſtained by a firm cellular plate, compacted into a kind of triangular ligament, which deſcends from the ſynchondroſis of the oſſa pubis, and is from thence continued into the denſe cellular ſtratum that ſurrounds the hard cavernous bodies.

DCCCXXXIV. The whole human penis forms a cylindrindrical body, depreſſed on the upper part, of variable magnitude; whoſe uſe is, to be received into the female parts of generation, and to carry thither prolific ſemen.

DCCCXXXV. Theſe cavernous bodies then of the penis, having their ſpungy fabric diſtended in coition by the blood retained by the veins, and ſtill propelled by the arteries, become rigidly turgid, and ſuſtain the otherwiſe flaccid or but weakly filled urethra, in ſuch a manner that it may be able to conduct the ſemen into the diſtant womb. All this is demonſtrated from the diſſection of brute animals in the act of venery, from an artificial erection, and from the injection of liquid matters into the veſſels of the penis. The cauſe is love, the deſire of pleaſure, the friction of the glans, various irritations of the bladder, teſticles, ſeminal veſſels, urethra, from the urine, from abundance of good ſeed, from the venereal poiſon, from cantharides, whipping with rods, or convulſion of the nerves. But the cauſe of this diſtention remains ſtill to be explained. The diſtribution of the blood-veſſels into the genital parts are therefore to be here deſcribed, to make it evident, how ready the compreſſing cauſe conſtantly is to act upon the veins.

DCCCXXXVI. The aorta at the fourth vertebra of the loins, and the vena cava at the fifth, are divided, the former before the latter. The common iliac branches, not yet arrived to the middle of the interval in the thighs, ſend off inward and downward a conſiderable artery, called the *hypogaſtric*, which in the fœtus is larger than the femoral artery, and in the adult is equal to it. This deſcending into the pelvis, divides into four, five, or ſix principal branches; of which the firſt is the *iliaca anterior*, which ſupplies branches upward to the dura mater, cauda equina, and loins, and afterwards into the os ſacrum. The next, or *ſacro-lateral* artery, goes off from the bone of that name, when it does not ariſe from the former; and the third, or *iliaca poſterior*, is diſtributed to the glutei muſcles. The fourth, the *iſchiatica deſcendens*, goes to ſeveral muſcles, nerves, and levators of the anus. The fifth trunk is that of the *hæmorrhoidea infima* or *pudenda communis*, which in the cavity of the pelvis ſends conſiderable branches to the bladder, and to the rectum gives the middle hemorrhoidal joined with the meſenterics; after which, going out of the pelvis, it creeps by the ſide of the obturator, and gives off the *external hæmorrhoidals* to the ſphincter and ſkin of the anus: then dividing, it goes with an internal branch to the bulb of the urethra and ſurface of the proſtate, where the external is again divided: here it enters deeply the cavernous body of the penis, and runs through its whole length; while by another branch often joined with the veſſels of the bladder, it runs along the back of the penis, according to the direction of its bodies, and terminates with them by ramifications into the ſkin. The ſixth is the *obturatrix*, ſpent upon the joint of the femur and adjacent muſcles. The laſt is the *umbilical artery*, to be deſcribed in treating of the fœtus; although in adults it ſends off ſome branches to the bladder, from its thick callous vagina. Sometimes one or more of theſe arteries come from the common trunk. The ſkin of the penis and ſcrotum have their arteries from the epigaſtric, and from the internal branch of the crural. Theſe external arteries communicate in many places with the internal.

DCCCXXXVII. The *veins* are, in general, diſtributed in like order with the arteries. They come off in two

trunks

trunks from the iliacs, joining together into a net; and then the *hæmorrhoidal* vein, bending round under the os pubis, forms a large plexus, ſpread with the veins of the pelvis upon the proſtate and ſeminal veſicles: from hence the *vena penis* ariſes, which is often ſingle, and furniſhed with valves to forward the return of the blood. The external veins of the penis and ſcrotum go to the ſaphena and crural, communicating in ſeveral places with the internal veins, more eſpecially at the baſis of the prepuce.

DCCCXXXVIII. *Lymphatic veſſels* of the penis are, by moſt eminent anatomiſts, ſaid to run under the ſkin towards the groins. The *nerves* of this part are both numerous and very large, and accompany the arteries of the penis from the trunk of the great ſciatic nerve[180]. But the bladder, rectum, and uterus, are ſupplied by the *lower meſenteric* plexus, which ariſes from the middle one, deſcending into the pelvis.

DCCCXXXIX. In order to diſtend the penis, there muſt be either a compreſſure of the vein (DCCCXXXIV.), bringing back the blood from the cavernous bodies of the penis or urethra; or at leaſt it is neceſſary that there be a conſtriction of the leſſer veins that every where open within the cavernous bodies, to hinder them from abſorbing and returning the blood from the arteries. The firſt, however, may be effected by the levator, drawing up the proſtate and bladder: but it is very probable, that, as we ſee in the nipples of the ſuckling mother, in the gills of the peacock, and in the bluſhing or redneſs of the face from paſſions of the mind, as well as from brute animals, which all couple without the uſe of any erector muſcle; from the erections which take place in animals totally different from man, and eſpecially thoſe which take place in birds very quickly; from the reſt of the erector muſcles themſelves in the libidinous erection of the penis, and from their unfitneſs for compreſſing the veins; from all theſe, I ſay, it is probable, that the courſe of the blood through the vein may be retarded, without the immediate uſe of any muſcle; and that, by the power of the numerous, ſmall, latent, nervous bridles, by whoſe conſtriction, from the force of pleaſure, the veins are compreſſed and ſtraitened, ſo as to return leſs blood to the trunks, at that time, than what is imported by the arteries, which are not only free from any ſtricture, but, by the increaſe of pulſation bring a greater quantity of blood, which cauſe alſo contributes to produce the erection. But the cauſe of this conſtriction in the nervous bridles or ſphincters themſelves depends upon a mechanical irritation of the nerves, and from ſomething more ſubtile, by which means the penis is immediately erected.

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[180] The bundles of the nerves of the penis are numerous and great, equalling almoſt the ſenſitive organs. The ſuperior ones have a double origin; the common plexus of the perinæum ariſes from the iſchiadic plexus, which produces the great dorſal nerve of the penis, that is diſtributed between the ſkin and lateral part of the corpora cavernoſa, as far as the gland itſelf: the inferior ſerve both the penis and ſcrotum.

DCCCXL. A long continued and violent erection is at laſt joined commonly with an expulſion of the ſemen; and this requires much greater force than is requiſite for the erection only. For the ſemen follows at that time when the irritation of the nerves is arrived at its greateſt height: and in natural venery indeed, when at length the cellular ſpaces of the urethra and its continuous glands, which are at laſt filled, become ſo far diſtended with a large quantity of warm blood, that the nervous papillæ, ſtretched out in the latter, become violently affected from the irritating or pleaſing cauſe; the ſeminal veſicles are emptied by the levator muſcles of the anus, which preſs them againſt the reſiſting bladder with a convulſive motion, excited either by a voluptuous imagination, or from the pruritus that is exquiſite in the nerves of the glans, principally in its lower part, which is in the neighbourhood of the frenum. Hence the ſemen is never diſcharged with any of the urine, in an healthy man; becauſe the expulſion of it requires the bladder to be cloſed or drawn up firmly together; for, while lax, it affords little or no reſiſtance to the ſeminal veſicles. The tranſverſe muſcles ſeem to dilate the canal of the urethra for the reception of the ſemen expreſſed from the veſicles.

DCCCXLI. Soon afterwards the powers conſtringing the urethra are, from the irritation of the very ſenſible fabric of that canal, put into action. To this conſtriction conduces principally the accelerator (DCCCII.), which makes a powerful concuſſion of the bulb and adjacent part of the urethra, ſo as to propel the contents more ſwiftly, in proportion as the bulb has a larger diameter than that of the urethra. But that this may act firmly, the ſphincter of the anus, together with that of the bladder, muſt be well ſhut. The accelerator muſcle ſeems alſo principally concerned in the erection, by compreſſing the veins of the corpus cavernoſum of the urethra. At the ſame time the *erectores penis*, as they are called, ariſing from the tubercles of the iſchium, become ſtrong, and are inſerted into the cavernous bodies, ſuſtaining the penis as a ſort of medium betwixt the tranſverſe and perpendicular direction. Thus the ſemen is drove into the vagina, and into the uterus itſelf, in a prolific coition: the whole action of which is very impetuous, and comes near to a convulſion; whence it wonderfully weakens the habit, and greatly injures the whole nervous ſyſtem, as the maladies ariſing from thence ſeem to indicate, in conſequence of the affection of the nerves, without which the ſemen cannot be expelled.

CHAP. XXX.

Of the VIRGIN UTERUS.

DCCCXLII. THE *uterus* is ſeated in the upper part of the pelvis, with the bladder before, and the rectum behind it, without adhering to either of them, and has its mouth turned a little forwards. In an adult woman, it is contained within the pelvis; but in an infant, it lies above it. In women, the peritonæum deſcends from the os pubis into the pelvis, over the poſterior face of the bladder, down to the bottom or mouth of the uterus: from whence again it aſcends over the foreſide of the uterus; and paſſing round its convexity, deſcends on the poſterior ſide down to the vagina, from whence it extends laterally or tranſverſely on each ſide, including the rectum with lunated folds, which is all the difference betwixt the female and male peritonæum. But this ſame peritonæum, coming into the pelvis from the iliac veſſels, and broadly adhering to the ſides of the uterus and vagina, is folded back over itſelf, and divides the pelvis into two parts, the anterior and poſterior, like a partition, under the denomination of *ligamentum latum*. Thus the peritonæum accurately connects the uterus, without the intervention of any fat, ſo as to ſerve it on all ſides as an external coat or covering. It does not, however, hinder the uterus from being totally free and moveable.

DCCCXLIII. The body of the uterus is uſually diſtinguiſhed from its neck. The body is flatly convex before and behind, with acute edges on each ſide and at the meeting of its convexities, but converging gradually afterwards for ſome way; in its upper part, moderately convex. It has a peculiar fabric, being made up of a cloſe, firm, but ſomewhat ſucculent and cellular fleſh, in which we perceive the appearance of muſcular fibres, more eſpecially in thoſe women that have born children: ſome of which fibres are flat, and mixed with one another into a kind of net-work; others run along the uterus longitudinally, from the bottom to the mouth of the uterus, diſpoſed in various circles, and particularly at the fundus betwixt the tubes, and likewiſe in the neck near the mouth. In beaſts, the uterus is manifeſtly muſcular; and in women, likewiſe, gives evident ſigns of a contractile power. Its outer coat is received from the peritonæum. As for any mucous ſinuſes variouſly branching and dividing within the fleſh of the uterus, after repeated inquiries we now declare, that we have not been able to find any; only ſome veins, ſurrounded with cellular ſubſtance, by which their diameters

meters

meters are ſuſtained. The internal membrane of the uterus is continued from the cuticle; in the upper part of the cavity fleecy; and in the lower part callous, and valvular. The cavity of the uterus is ſmall, for the moſt part triangular upward, and below like a compreſſed cylinder. The cylindric part, which is called the *cervix* or *neck*, is compreſſed, thick, and has alſo a cylindric cavity within. It is altogether rough, with callous wrinkles riſing up into an edge; whence they incline towards the vagina. Theſe recede laterally from the anterior and poſterior margin, joining together by ſmall wrinkles, in the intervals of which are ſmall mucous ſinuſes, with ſmall pellucid ſpherules, filled with a very clear liquor, in ſome parts interſperſed through the upper region of the cervix uteri, differing both in their number and magnitude. It is not uncommon for the uterus to be diſtinguiſhed by a line or protuberance extended through its middle. The cervix is terminated by the os internum uteri, with a tranſverſe rim, forming protuberant lips, which project for ſome length into the vagina, are received by its blind extremity, and project into it obliquely forward. But it is full of mucus, and mucous ſinuſes ſituated in its ſwelling lip.

DCCCXLIV. The triangular part of the uterus ſends out, from its lateral angles, canals, in ſome meaſure folded together by the cellular ſubſtance, growing gradually broader, and being again a little contracted towards their extremity, they proceed towards the ovary, firſt in a tranſverſe direction, and afterwards a little deſcending, but with ſome variation, under the denomination of the uterine *tubes*. Their external membrane is from the peritonæum: for they are included within the duplicature of the broad ligament, which is a production of that membrane; internally they are wrinkled almoſt reticularly, lined with mucus, extended to a conſiderable length by intervening plates or folds which broadly crown the opening of the tube, which is alſo connected to the ovary. Betwixt the two membranes is ſomething of a ſpungy cellular ſubſtance, of a ſlender texture. They alſo contain uſually a mucus, the origin of which is not known. There are alſo great numbers of veſſels, and perhaps ſome muſcular fibres, but the latter are more obſcure. They are ſupported by the proper fold of the peritonæum which goes out from the broad ligament.

DCCCXLV. But the *ovaries*, included in the ſame duplicature of the broad ligament behind the tubes, are ſeated tranſverſely, and conjoined to theſe tubes by a ligamentary expanſion of their own, which is long enough to allow them a free motion. They are ſomewhat of an oblong or oval figure, depreſſed on each ſide, convex upon their unconnected ſide, and half elliptical; but that which is connected with the ligament is ſtraight. Their membrane, which comes from the peritonæum, is thick, and almoſt cartilaginous. Their fabric nearly enough reſembles that of the uterus itſelf; being a cloſe, white, cellular ſubſtance, compacted together, without any fat. The margin of the broad ligament, receding from the uterus to ſuſtain the ovary, has ſomething of a more ſolid and thick ſubſtance, reſembling a ligament, yet is not a hollow or true canal.

DCCCXLVI. But in the ovary even of a tender virgin, are ſituated round veſicles made of a pretty ſtrong pulpy membrane, connected every where to the ovarium by cellular threads, which are filled with coagulable lymph; of an uncertain number and magnitude, being found in one ovary to fifteen and upwards. Theſe remarkable bodies are found very widely diffuſed thro' all animals, even ſuch as have but one ſex.

DCCCXLVII. Laſtly, the uterus ſends out from the ſame lateral angles of its triangular body downward, a kind of faſciculus, compoſed of long cellular fibres and ſmall veſſels [181], which, becoming ſmall in its progreſs, goes out of the pelvis through the ring of the abdomen (DCCCXII.) into the groin, where it ſplits into branches, and diſſolves into ſmall veſſels, which communicate with the epigaſtrics. Whether or no it has any long fibres propagated from the uterus itſelf, does not plainly appear.

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[181] They grow to a remarkable ſize during pregnancy, along with the other ſpermatic and uterine veſſels; and this bundle abounds with many lymphatic veſſels, which is called, though not very properly, *teres ligamentum uteri*. Dr Hunter has given an excellent drawing of it.

DCCCXLVIII. The arteries of the uterus are from the hypogaſtrics; a conſiderable branch of which goes off, like that to the bottom of the bladder in men; or at leaſt it ariſes from the umbilical trunk, or immediately below that trunk, and makes the common artery belonging to the uterus, bladder, and rectum. It ſpreads on the lower parts of the uterus, almoſt at the extremity of its neck; and, aſcending upwards, ſends tranſverſe inflected branches to the uterus, makes numerous anaſtomoſes with the ſpermatics, and often gives arteries to the tube itſelf. Another plexus of branches tends downwards to the vagina, and follows it a long way; although there is otherwiſe a proper vaginal artery originating in the pelvis, and branches ſometimes come from the meſocolic. There are alſo ſeminal veſſels which have the ſame origin as in men; and form a plexus, which, from its ſimilitude to the tendrils of a vine, is called *pampiniformis*. This plexus, deſcending over the pſoas muſcle into the pelvis, divides into two plexuſes. The poſterior ſurrounds the ovary itſelf, with many circles, elegantly diſtributed through its ſubſtance and the ova themſelves. The anterior both ſupplies the tube, and deſcends to the uterus itſelf, in which it ſends out winding branches upward and downward, and ſome branches that are detached to the bladder. Another artery is the middle hæmorrhoidal, coming from the common trunk of the pundendal, a conſiderable way forward with the vagina; to which, and to the bladder and rectum, it is diſtributed. The beginning of the vagina likewiſe, and the clitoris, have arteries from the external hemorrhoidal, which are diſtributed like thoſe of the penis, ſome inwardly, others ſu-

ſuperficially, both of which inoſculate with the veſical branch.

DCCCXLIX. The courſe of the uterine veins is like to that of the arteries, originating from the trunks of the hypogaſtrics; they are the internal uterine, the vaginal, the middle hemorrhoidal, the external circumflex, and thoſe of the clitoris. But they make a remarkable plexus on each ſide, which occupies the ſides of the vagina below the clitoris. Below that, it is joined into a continued plexus with its companion on the other ſide. A plexus alſo from the external hemorrhoidal, and joined with the veſical veſſels, goes to the clitoris, as well as to the penis. It has no valves, except a few in the ſpermatics. Theſe, in a very large bundle, go to the ovarium, and alæ veſpertilionis.

DCCCL. Within the uterus itſelf the arteries terminate in exhaling branches on its internal cavity. By childbirth theſe go off into little pendulous productions, like very ſmall eels. Thus the veins of the uterus are at the ſame time very large ſinuſes; for the veins are enormouſly augmented, and open with very large mouths into their cavity.

DCCCLI. Lymphatic veſſels are found in the uterus of brutes, but more rarely in the human; they have been obſerved, however, by very eminent anatomiſts.

DCCCLII. The nerves are ſupplied from the lower meſocolic plexus, united with thoſe of the ſacrum, which ſends out large branches to the bladder, womb, and rectum; beſides which, there are a few nervous twigs that deſcend through the broad ligament to the ovaries, and others from the nerve that goes with the veſſels to the clitoris. But the ovary has alſo its proper nerves from the renal plexus, ſimilar to thoſe which go to the teſticles of the male. The great number of the nerves, therefore, make theſe parts extremely ſenſible.

DCCCLIII. The deſcriptions we have hitherto given, are in common to all ages of the female; but about the 13th year, or ſomewhat later, nearly at the ſame time when ſemen begins to form itſelf in the male, there are likewiſe conſiderable changes produced in the female. For at this time the whole maſs of blood begins to circulate with an increaſed force, the breaſts ſwell out, and the pubes begins to be cloathed: at the ſame time the menſes in ſome meaſure make their appearance by a common law of nature, although in different countries both the time and quantity of the flux is different.

DCCCLIV. But, before the menſtrual flux, there are various ſymptoms excited in the loins, heavy pains, ſometimes like colic pains, with an increaſed pulſe, headachs; and cutaneous puſtules commonly precede, and a white juice commonly flows from the uterus. For now the fleecy veſſels of the uterus, which in the ſtate of the fœtus were white, and tranſuded a ſort of milk, as in the young girl they tranſuded a ſerous liquor, do now begin to ſwell with blood; the red parts of which are depoſited through the veſſels into the cavity of the uterus. This continues ſome days, while in the mean time the firſt troubleſome ſymptoms abate, and the uterine veſſels, gradually contracting their openings, again diſtil only a little ſerous moiſture as before. But then the ſame efforts return again at uncertain intervals in tender virgins; till at length, by degrees, they keep near to the end of the fourth week; at which time follows the flux of blood, as before, which is periodically continued to about the 50th year; though the diet, country, conſtitution, and way of life, cauſe a great variation in this diſcharge. Pregnancy commonly produces a temporary ſtoppage of the menſes.

DCCCLV. This diſcharge of blood from the veſſels of the uterus itſelf, is demonſtrated by inſpection in women who have died in the midſt of their courſes; and in living women, having an inverſion of the uterus, the blood has been ſeen plainly to diſtil from the open orifices: in others, in whom, when the menſes have been deficient, the uterus has appeared full of concreted blood. It alſo appears from the nature of the uterus itſelf full of ſoft ſpungy veſſels, compared with the thin, callous, by no means fleecy, and almoſt bloodleſs ſubſtance of the vagina. That this is good blood in an healthy woman, appears both from the foregoing and innumerable other obſervations. Nevertheleſs nothing hinders the blood from being ſent forth through the vagina, as in other caſes it is through the inteſtinum rectum, and in ſhort through the remoteſt parts of the body.

DCCCLVI. Since none but the human ſpecies are properly ſubject to this menſtrual flux of blood (altho' there are ſome animals who, at the time of their vernal copulation, diſtil a ſmall quantity of blood from their genitals), and ſince the body of the male is alway free from the like diſcharge, it has been a great inquiry in all ages, what ſhould be the cauſe of this ſanguine excretion peculiar to the fair ſex. To this effect the attraction of the moon, which is known to raiſe the tides of the ſea, has been accuſed in all ages; others have referred it to a ſharp ſtimulating humour, ſecreted in the genital parts themſelves, the ſame which is the cauſe of the venereal diſeaſe. But if the moon was the parent of this effect, it would appear in all women at the ſame time; which is contrary to experience, ſince there is never a day in which there are not many women ſeized with this flux; nor are there fewer in the decreaſe than the increaſe of the moon. As to any ſharp ferment ſeated in the uterus or its parts, it will be always inquired for in vain; where there are none but mild mucous juices, and where venery, which expels all thoſe juices, neither increaſes nor leſſens the menſtrual flux: and women deny that, during the time of their menſes, they have any increaſed deſire of venery; ſeeing at that time moſt of the parts are rather pained, and languid; and the ſeat of venereal pleaſure is rather in the entrance of the pudendum than in the uterus, from which laſt the menſes flow. But, laſtly, that the menſtrual blood is forced out by ſome cauſe exciting the motion of the blood againſt the veſſels, appears from hence, that, by a retention, the courſes have been known to break through all the other organs of the body, where no vellicating ferment could be ſeated, even ſo as to burſt open the veſſels of each organ; and that the effect produced by the retention of the blood, is not confined to thoſe parts which pour out the venereal humour.

DCCCLVII. Nature has, in general, given women a more delicate body, and ſolids that are leſs elaſtic; their muſcles are alſo ſmaller, with a greater quantity of fat interpoſed both betwixt them and their fibres; the bones too are ſlenderer, and their ſurfaces have fewer proceſſes and aſperities. Moreover, the pelvis of the female is, in all its dimenſions, larger; the oſſa ilia ſpread farther from each other; and the os ſacrum recedes more backward from the bones of the pubes, while the oſſa iſchii depart more from each other below; however, the angle in which the bones of the pubes meet together to form an arch, is in the female remarkably more large; which differences are confirmed by the obſervations of the great anatomiſts; and from neceſſity itſelf, which requires a greater ſpace for a greater number of viſcera in the pelvis. Moreover, the uterine arteries are conſiderably large, more ſo than in men; and have a greater proportion of light, with reſpect to the thickneſs of their coats: but the uterine veins are, in proportion, leſs than in men; and of a more firm reſiſting texture, than in other parts of the body. From hence it follows, that the blood, brought by the arterial trunk to the womb, by paſſing from a weaker artery into a narrow and more reſiſting vein, will meet with a more difficult return, and conſequently diſtend the uterine veſſels.

DCCCLIX. The female infant new-born has her lower limbs very ſmall; and the greater part of the blood, belonging to the iliac arteries, goes to the umbilicals, ſending down only a ſmall portion to the pelvis. Hence the pelvis is ſmall, and but little concave; ſo that the bladder and uterus itſelf, with the ovaries, project beyond the rim of the pelvis. But when the fœtus is born, and the umbilical artery is tied, all the blood of the iliac artery deſcends to the pelvis and lower limbs, which of courſe grow larger, and the pelvis ſpreads wider and deeper: ſo that, by degrees, the womb and bladder are received into its cavity, without being any longer compreſſed by the inteſtines and peritonæum, when the abdominal muſcles preſs upon the lower parts of the abdomen. When now the increaſe is perfect, or next to it, then in general we find thoſe arteries of the uterus largeſt, which in the fœtus were leaſt, and eaſily injected with wax; and all things are changed in ſuch a manner, that the hemorrhoidal artery is now in place of the hypogaſtric (DCCCXXXVI.), when formerly the umbilical had been the trunk of that artery. More blood, therefore, at that time comes into the uterus, vagina, and clitoris, than formerly uſed to do.

DCCCLX. At the ſame time, when the growth of the body begins conſiderably to diminiſh, and the blood, finding eaſy admittance into the completed viſcera, is prepared in a greater quantity, the appetite being now very ſharp, in both ſexes, a plethora conſequently follows. In the male, it vents itſelf frequently by the noſe, from the exhaling veſſels of the pituitary membrane being dilated to ſo great a degree without a rupture, as to let the red blood diſtil through them (CCCCLVIII.); and now the ſemen firſt begins to be ſecreted, and the beard to grow. But in the female, the ſame plethora finds a more eaſy vent downward; being that way directed partly by the weight of the blood itſelf, to the uterine veſſels now much enlarged, of a ſoft fleecy fabric, ſeated in a looſe hollow part, with a great deal of cellular fabric interſperſed, which is very yielding and ſucculent, as we obſerve in the womb: for theſe cauſes, the veſſels being eaſily diſtendible, the blood finds a more eaſy paſſage through the very ſoft fleecy exhaling veſſels, which open into the cavity of the uterus, as being there leſs reſiſted than in its return by the veins, or in taking a courſe through any other part;

becauſe, in females, we obſerve the arteries of the head are both ſmaller in proportion, and of a more firm reſiſting texture. The return of the ſame is therefore more ſlow, both becauſe the flexures of the arteries, from the increaſed afflux of the blood, become more ſerpentine and fit for retarding the blood's motion, and likewiſe becauſe it now returns with difficulty through the veins. The blood is, therefore, firſt collected in the veſſels of the uterus, which at this time, by repeated diſſections, are obſerved to be ſwelled; next it is accumulated in the arteries of the loins and the aorta itſelf, which, urging on a new torrent of blood, augments the force, ſo far as to diſcharge the red blood into the ſerous veſſels, which at firſt tranſmit an increaſed quantity of warm mucus, afterward a reddiſh-coloured ſerum; and by ſuffering a greater diſtention, they at laſt emit the red blood itſelf. The ſame greater impulſe of blood, determined to the genital parts, drives out the hitherto latent hairs, increaſes the bulk of the clitoris, dilates the cavernous plexus of the vagina, and whets the female appetite to venery. Accordingly we find, that the quantity of the menſtrual flux, and the earlineſs of their appearance, are promoted by every thing that either increaſes the quantity or momentum of the blood with reſpect to the body in general, or which direct the courſe of the blood more particularly towards the uterus; ſuch as joy, luſt, bathing of the feet, a rich diet, warm air, and lively temperament of body. It is diminiſhed by thoſe things which leſſen plethora and the motion of the blood, as want, grief, cold air, ſloth, and antecedent diſeaſes.

DCCCLXI. When ſix or eight ounces of blood have been thus evacuated, the unloaded arteries now exert a greater force of elaſticity, and, like all arteries that have been overcharged with blood, contract themſelves by degrees to a leſs diameter, ſo as at length to give paſſage only to the former thin exhaling moiſture; but the plethora or quantity of blood, being again increaſed from the ſame cauſes, a like diſcharge will always more eaſily enſue through the veſſels of the uterus, after they have been once thus opened, than through any other part. Nor is there any occaſion to perplex ourſelves about the cauſe, why this periodical diſcharge is, for the moſt part, nearly regular or menſtrual; for this depends upon the proportion of the quantity and momentum of the blood daily collected, together with the reſiſtance of the uterus, which is to yield again gradually to the firſt courſe. Therefore this critical diſcharge of blood never waits for the interval of a month, but flows ſooner or later, according as the greater quantity of blood in plethoric women is determined, by luſt or other cauſes, towards the uterus. Finally, they ceaſe to flow altogether, when the uterus, like all the other ſolid parts of the body, has acquired ſo great a degree of hardneſs and reſiſtance, as cannot be overcome by the declining force of the heart and arteries, by which the blood and juices are driven on through all the veſſels. This increaſed hardneſs in the old uterus is ſo remarkable in the arteries and ovaries, that it eaſily diſcovers itſelf both to the knife and the injections of the anatomiſt. But, in general, brute animals have no menſes; becauſe, in them, the womb is in a manner rather membranous than fleſhy, with very firm or reſiſting veſſels, which, with the difference of their poſture, never permit a natural hemorrhagy from the noſtrils or other parts. They are wanting in men, becauſe in that ſex there is no ſpungy organ fit for retaining the blood; and likewiſe becauſe the arteries of the pelvis are both harder and leſs, in proportion, than the veins; and thus the impetus of the blood in the lower limbs is turned away, whoſe veſſels in men are larger, as thoſe of the pelvis are ſmaller.

DCCCLXII. It will, perhaps, be demanded, why the breaſts ſwell out at the ſame time with the approach of the menſes? We are to obſerve, that the breaſts have many particulars in their fabric, common to that of the uterus; as appears from the ſecretion of the milk in them after the birth of the fœtus, which increaſes or diminiſhes in proportion as the lochial flux is either increaſed or diminiſhed;

miniſhed; from the ſimilitude of the ſerous liquor, like whey, found in the uterus, ſo as to reſemble milk, in thoſe who do not ſuckle their children, being of a thin and white conſiſtence, appearing very evidently in brute animals; alſo from the turgeſcence or erection of the papillæ or nipples of the breaſt by friction, analogous to the erection of the clitoris. Therefore, the ſame cauſes which diſtend the veſſels of the uterus, likewiſe determine the blood more plentifully to the breaſts; the conſequence of which is an increaſed bulk and turgeſcence of the conglomerate glandules and cellular fabric which compoſe the breaſts.

CHAP. XXXI.

Of CONCEPTION.

DCCCLXIII. THIS is a very arduous inveſtigation, as we propoſe to diſcover the changes which take place in the inward parts of woman, when a new creature begins to germinate, who is, in proper time, to be expoſed to light. We ſhall relate, in the firſt place, therefore, thoſe things which experience ſhows to be true; and then add thoſe hypotheſes by which learned men have endeavoured to ſupply ſuch things as are not evident from the ſubject itſelf. How few things are aſcertained on this ſubject, and how difficultly they are aſcertained, I have learned by too much experience.

DCCCLXIV. That ſome light may be thrown on ſuch a dark ſubject, we ſhall begin with the moſt ſimple animals, and afterwards take notice of what nature has added in others whoſe fabric is more compounded. The ſmalleſt animals, then, which have very few or no limbs, the leaſt diſtinction of parts, the ſhorteſt life, the vital functions both few and very ſimilar to one another; theſe animals bring forth young ones like themſelves, with no diſtinction of ſexes, as all of them are fruitful, and none imparts fecundity to the reſt. Some of them exclude their young whom they have conceived in their body, through a certain cleft; from others, ſome limbs fall off, which are completed into animals of a kind ſimilar to thoſe from which they have fallen off. This kind of generation is extended very wide, and comprehends the greater part of animal life.

DCCCLXV. The next to theſe, which are a little more compounded, all bring forth their young; yet in ſuch a manner, that in their bodies is generated a certain particle peculiar to themſelves, diſſimilar to the whole animal, and contained in ſome involucra, within which lies the animalcule that is afterwards to become ſimilar to that within which it is produced; this is commonly called an *egg*. A great part of theſe animals is immoveable.

DCCCLXVI. The animals which follow are not indeed numerous, but have both eggs, and male ſemen beſides; ſo that both ſexes are joined in the ſame animal. But we call it *male ſemen*, becauſe it is neceſſary for ſprinkling the eggs in order to render them prolific, although it never grows alone into a new animal. In this claſs, therefore, a juice is prepared by its own proper organs, which is likewiſe poured on the eggs through organs proper to itſelf, but different from the former, in order to generation.

DCCCLXVII. Thoſe animals are much more numerous which have both a male juice and female eggs; yet ſuch as cannot fecundate themſelves, but require true coition. For two animals of this kind agree in the work of fecundation, in ſuch a manner, that each impregnates the other with its male organs, and again ſuffers itſelf to be impregnated in its female ones by the male parts of the other.

DCCCLXVIII. And now the nature of animals approaches nearer and nearer to that of the human race; of which, namely, ſome individuals of a ſimilar kind have only male organs, and the ſame males ſprinkle their ſeed on the female eggs of others. Very many cold ones ſprinkle their ſeed upon the eggs after they are poured out of the body of the mother. Warm animals inject their ſemen into the uterus of the female. But now, if eggs are generated within the body of the female, they are brought forth covered with ſhells or membranes; but if the female has a live fœtus in its uterus, it is born quite free of any involucrum: but the difference between theſe oviparous and viviparous animals is but ſmall; ſo that in the ſame claſs, and the ſame genus, ſome animals lay eggs, others produce live fœtuſes; and laſtly, the ſame animal ſometimes lays eggs, and ſometimes brings forth live young.

DCCCLXIX. From this review of animals it appears, that all animals are produced from others ſimilar to themſelves; many from a part of it ſimilar to the whole; others from an egg of a peculiar ſtructure; but that all theſe do not ſtand in need of male ſemen. Laſtly, the more moveable and lively animals only, whoſe bodies are of a more complicated ſtructure, are endowed with a double ſyſtem for generation; and the difference of ſexes ſeems to be added for the bond of ſocial life, and for the ſafety of a leſs numerous progeny.

DCCCLXX. For the certain effuſion of this male juice into the female organs, both ſexes are inflamed with the moſt vehement deſires; the male indeed has the moſt lively ones, becauſe the female is at all times ready to ſuffer the venereal congreſs; and thence it behoves the male to be animated with a deſire of venery, when he has plenty of good feed, and ſuch as as is of a prolific nature. Therefore this is the greateſt cauſe of venereal deſire in him; but in females, of the brute kind eſpecially, ſome kind of inflammation in the vagina, which excites an intolerable itching.

DCCCLXXI. But nature has firſt added to the womb, both in women and in quadrupeds, a vagina or round membranous cavity, eaſily dilatable, which, as we have already ſeen (DCCCXLIII.), embraces and ſurrounds the projecting mouth of the uterus; from whence it deſcends obliquely forward under the bladder, and reſting upon the rectum with which it adheres, and laſtly opens under the urethra with an orifice a little contracted. This opening, in the fœtus and in virgins, has a remarkable wrinkled valve, formed as a production of the ſkin and cuticle, under the denomination of *hymen*, which ſerves to exclude the air or water; not perhaps without ſome kind of moral uſe, ſeeing this membrane, as far as I know, is given to women alone. It is circular, excepting a ſmall deficiency under the urethra, which yet is not always conſtant, but it turns broader towards the anus. This membrane being inſenſibly worn away by copulation, its lacerated portions at laſt diſappear. The caruncles, which are called *myrtiformes*, are partly the remains of the ſhattered hymen, and laſtly the valves of the mucous lacunæ hardened into a kind of fleſh.

DCCCLXXII. The fabric of the *vagina* is ſomewhat like that of the ſkin, compoſed of a firm, denſe, or callous cuticle, covering a thick, white, nervous ſkin, in which, more eſpecially at its end, appear fleſhy fibres. Its internal ſurface is, in a great meaſure, rough, beſet with many callous warts, which, though hard, are ſenſible: beſides which, there are thin plates, terminated with a protuberant inclined edge, pointing downward, ſo as to form two principal rows, ſpreading betwixt thoſe warts; and of theſe, the uppermoſt are extended under the urethra, where they are larger, as the lower are incumbent on the anus. From each of theſe to the other are continued, on both ſides, ſeveral rows of leſſer valve-like papillæ, variouſly inflected into arches, and which ſeem to be deſigned for increaſing the pleaſure, and facilitating the expanſion, when it is called for. It is furniſhed with a proper mucus of its own, ſeparated from particular ſinuſes in ſeveral parts, but more eſpecially in its poſterior and ſmoother ſide.

DCCCLXXIII. At the entrance of the vagina are prefixed two cautaneous productions or appendages, called *nymphæ*, continued from the cutis of the clitoris, and from the glans itſelf of that part; and theſe, being full of cellular ſubſtance in their middle, are of a turgeſcent or diſtenſible fabric, jagged and repleniſhed with ſebaceous glandules on each ſide, ſuch as are alſo found in the folds of the prepuce belonging to the clitoris. Their uſe is principally to direct the urine, which flows betwixt them both from the urethra, that in its deſcent it may be turned off from clinging to the body, in which office the nymphæ are drawn together with a ſort of erection. Theſe membranous productions deſcend from the cutaneous arch ſurrounding the *clitoris*, which is a part extremely ſenſible, and wonderfully influenced by titillation; for which it is made up, like the penis, of two cavernous bodies, ariſing in like manner from the ſame bones, and afterwards conjoining together in one body, but without including any urethra. It is furniſhed with blood-veſſels, nerves, and levator muſcles, and a ligament ſent down from the ſynchondroſis of the os pubis, like thoſe in men, like unto which the clitoris grows turgid and erect in the time of coition, but leſs in thoſe who are very modeſt; but from friction, the clitoris always ſwells up and is erected.

DCCCLXXIV. The muſcle, termed *oſtii vaginæ conſtrictor*, ariſing on each ſide from the ſphincter of the anus, and increaſed by the acceſſion of a branch from the os iſchium, covers the vaſcular plexus, from whence it proceeds outward in the direction of the labia externa, and is inſerted into the crura clitoridis; thus it ſeems to compreſs the lateral venal plexuſes of the vagina, whence it every way conduces to retard the return of the venal blood. The tranſverſe muſcle of the urethra, and the bundle from the ſphincter inſerted into it, have the ſame ſituation as in men.

DCCCLXXV. When a woman is invited either by moral love, or a luſtful deſire of pleaſure, and admits the embraces of the male, the penis, entering the vagina, rubs againſt its ſides, until the male ſeed breaks out and is poured into the uterus. In like manner the attrition of the very ſenſible and tender parts, which lie within the vagina, excites a convulſive conſtriction, as we obſerved before of the male (DCCCXL.) By theſe means the return of the venous blood being ſuppreſſed, the clitoris grows turgid and erect, more eſpecially in luſtful women; the nymphæ ſwell on each ſide, as well as the venal plexus, which almoſt ſurrounds the whole vagina, ſo as to raiſe the pleaſure to the higheſt pitch: in conſequence of which there is expelled, by the muſcular force of the conſtrictor (DCCCLXXIV.), but not perpetually, nor in all women, a quantity of lubricating mucous liquor, of various kinds. The principal fountains of this are ſeated at the firſt beginning or opening of the urethra, where there are large mucous ſinuſes placed in the protuberant margin of this uriniferous canal. Moreover, there are two or three large mucous ſinuſes, which open themſelves into the cavity of the vagina itſelf, at the ſides of the urethra, in the bottom of the ſinuſes which are formed by the membranous valves ſulcated upward. Laſtly, at the ſides of the vagina, betwixt the bottoms of the nymphæ and the hymen, there is one opening, on each ſide, from a very long duct; which, deſcending towards the anus, receives its mucus from a number of very ſmall follicles.

DCCCLXXVI. But the ſame action which, by increaſing the pleaſure to the higheſt degree, cauſes a greater conflux of blood to the whole genital ſyſtem of the female (DLXIII.), occaſions a much more important alteration in the interior parts. For the hot male ſemen, penetrating the tender and ſenſible cavity of the uterus, which is itſelf now turgid with influent blood, does there excite, at the ſame time, a turgeſcence and diſtention of the lateral tubes, which are very full of veſſels, creeping betwixt their two coats, and now ſtiff with the great quantity of blood they contain; and theſe tubes, thus copiouſly filled and florid with the red blood, become erect, and aſcend, ſo as to apply the ruffle or fingered opening of the tube to the ovary. In the truth of all theſe particular changes, we are confirmed by diſſections of gravid or pregnant women, under various circumſtances; alſo from the comparative anatomy of brute animals, and from the appearances of the parts when diſeaſed.

DCCCLXXVII. But, a in female of ripe years, the ovary is extremely turgid, with a lymphatic fluid, which will harden like the white of an egg, and with which little bladders are diſtended. In a prolific copulation, ſome one of the more ripe veſicles is burſt, a cleft manifeſtly appears, and at length pours out a clot of blood. Within this veſicle, after copulation, a kind of fleſh grows up, at firſt flocculent, than granulated, and like a conglomerate gland, conſiſting of many kernels joined together by a cellular ſubſtance; which fleſh by degrees becoming larger and harder fills the whole cavity of the veſicle, and is hardened into the nature of a ſcirrhus, in which, for a long time, remains a cleft, or a veſtige of one. This is the *corpus luteum*[182], common to all warm quadrupeds, in which ſome late anatomiſts have found a ſort of juice before copulation; which, however, experience does not admit, ſeeing there is no corpus luteum at that age. Nor is the veſicle, which is the human ovum, contained in a body like a cup.

DCCCLXXVIII. The extremity of the tube, therefore, ſurrounding and compreſſing the ovarium in a prolific congreſs, is thought to preſs out and ſwallow a mature ovum, from a fiſſure in the outer membrane, from whence it is continued down by the periſtaltic motion of the tube, to the uterus itſelf; which periſtaltic motion begins from the firſt point of contact with the ovum, and urges the ovum domnward ſucceſſively to the opening into the fundus uteri, which is very manifeſt in brute animals. The truth of this appears from the conſtant obſervation of a ſcar or fiſſure in the ovarium, which is produced there after conception; from

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[182] The nnmber of corpora lutea for the moſt part correſponds with that of the fœtuſes: you will eaſily ſee a pretty mechaniſm in ſwine; whoſe ovaria are the likeſt, of all quadrupeds, to true ovaria. In any corpus luteum we diſtinguiſh as if a double ſubſtance, like a cortical and medullary part. Hunter has given elegant repreſentations of them; and we have very good deſcriptions of them from Bertrand and Huber.

from a fœtus being certainly found in quadrupeds, both in the ovarium of the female, and in the tube; from the analogy of birds, in which the deſcent of the ovum from the ovarium is very manifeſt. Yet we muſt acknowledge, that a true ovum was never found in quadrupeds, unleſs after a long time. It is probable, that at the time of conception, the true ovum is almoſt fluid, very ſoft and pellucid, and cannot be diſtinguiſhed from the mucus with which the tube is filled; likewiſe, that it is very ſmall, on account of the narrowneſs of the tube. The veſicle itſelf which was in the ovary remains in it fixed, and becomes the covering of the corpus luteum. But the accounts of ova ſaid to have fallen from women during the firſt days are not certain, and are contradicted by the ſmallneſs of the fœtus obſerved many days after conception; by the ſhape in which it is firſt obſerved, which is always oblong, and in brutes even cylindrical; and likewiſe by the ſmallneſs of the tube.

DCCCLXXIX. Theſe things are performed, not without pleaſure to the future mother, nor without a peculiar ſort of ſenſation of the internal parts of the tube, threatening to induce a ſwoon. Neither is the place of conception in the uterus, to which certain experience ſhews that the male ſemen comes. For the power of the male ſemen fecundates the ovum in the ovaria themſelves, as we ſee in the caſe of fœtuſes found in the ovaries and tubes; from the analogy of birds, in which by copulation one egg indeed falls into the uterus, but very many are fecundated at once in the ovaria. Nor is the ſmall quantity of the male ſemen, or its ſluggiſh nature, any objection to this, which by eminent anatomiſts has been thought to render it leſs fit for performing ſuch a journey. For it is certain that the male ſemen fills the tubes themſelves at the firſt impregnation, both in women and brute animals.

DCCCLXXX. The uterus indeed, in animals certainly, and in women probably, is cloſed, leſt the very ſmall ovum, together with the hope of the new progeny, ſhould periſh. At that time the new mother ſuffers many diſagreeable affections; which probably ariſe from the ſubputrid and ſubalkaline male ſemen reſorbed into the blood. A nauſea is occaſioned by conception, almoſt in the ſame manner as by ſwallowing a bit of a rotten egg. Fleſh is at this ſame time chiefly nauſeated; a vomiting alſo occurs; ſome puſtules break out, and the teeth ach. The moſt of theſe complaints I reckon to be owing to the ſwelling of the uterus, and the retention of the menſes.

DCCCLXXXI. Theſe changes, hitherto, which are proved at leaſt by the teſtimony of our ſenſes, may be either confirmed or corrected. Thoſe which follow are more conjectural; and the more difficult on account of the paucity of experiments, and their diſagreement with one another. And in the firſt place, it is a difficult queſtion, From whence proceed the firſt ſtamina of the new animal? Whether are they from both parents, and mixed into one animal by a conjunction of ſeminal matter coming from the whole body; as indeed there is a reſemblance of the fœtus to both parents in animals, but eſpecially in plants, as confirmed by very many experiments: the ſame thing alſo ſeems confirmed by the faults of parents being conveyed to their children. But no ſeed has ever certainly been obſerved in females; and innumerable examples ſhow, that the ſpecies of animals may be propagated without any mixture of ſeeds. Laſtly, the reſemblance of the young animal to its father ſeems only to ſhow, that in the male ſeed there is ſome power, which alone can form the ſoft matter of the embryo in its leaſt ſtate; juſt in the ſame manner as that power adds length to the pelvis in certain bodies, dilates the larynx, and cauſes the horns appear.

DCCCLXXXII. To the father ſome have attributed every thing; chiefly ſince the ſeminal worms, now ſo well known, were firſt obſerved in the male ſeed by the help of the microſcope, which are obſerved with truth to agree in figure with the firſt embryos of all animals. But in theſe animals there is a proportion wanting betwixt their number and that of the fœtuſes; they are alſo not to be conſtantly obſerved through all the different tribes of animals; they have too great a reſemblance to thoſe animalcules that are every where ſpontaneouſly produced in other juices, which yet are always tenacious of their own genus, and are never found to grow in the moſt diſſimilar kinds of animals that have limbs.

DCCCLXXXIII. Again, other anatomiſts, not leſs celebrated or leſs worthy of credit, have taught that the fœtus exiſted in the mother and maternal ovary; which the male ſemen excites into a more active life, and likewiſe forms it variouſly, ſo as to ſhow it juſt brought into life, and make its preſence manifeſt. That yolks are alſo manifeſtly found in the female ovaries, even altho' they have not been impregnated with any male ſemen. But a yolk is known to be an appendix to the inteſtine of fowls; and to have its arteries from the meſenteric artery, and the covering of the yolk to be continued with the nervous membrane of the inteſtine, which is continuous with the ſkin of the animal. That along with the yolk, therefore, the fœtus ſeems to be preſent in the mother hen, of whom the yolk is a part, and which gives veſſels to the yolk. Laſtly, that the analogy of nature ſhows that many animals generate eggs without any connection with a male of the ſame ſpecies, but that a male animal never becomes prolific without a female. That the progreſſions are continued from a female quadruped to an oviparous animal, and from that to one which is not oviparous; but that the new animal proceeds from a part of the old one. Certainly, therefore, the males muſt give ſome addition to that ſex which produces the fœtus from its own body; which addition is neceſſary in ſome tribes of animals, but in others, even the moſt fruitful, may be wanted. And that it is not poſſible with any kind of truth to admit of any inſertion, by which the open navel of the male animal, when conceived, ſhould adhere to the veſſels of the female. For this navel would be by far too ſmall at the time when the yolk is of a conſiderable bigneſs; neither could the very ſmall umbilical arteries be applied to the very large yolk with any hope of a continuance of the circulation.

DCCCLXXXIV. Thus much concerning the materials: but we are again at a loſs concerning the formation, by what means the rude and ſhapeleſs maſs of the firſt embryo is faſhioned into the beautiful ſhape of the human body. We readily reject ſuch cauſes as a fortuitious concourſe of atoms, the blind attractions between the particles of the nutritious juices, and the ſtrength of ferments, inconſcious of the reaſons why they operate; the ſoul is certainly an architect unequal to the taſk of producing ſuch a beautiful fabric; as for internal models, of which I never could conceive one clear idea in my mind, we ſhall refer them to thoſe hypotheſes which the deſire of explaining thoſe things, of which we are unwillingly ignorant, has given riſe to.

DCCCLXXXV. To me, indeed, experience ſeems to agree with thoſe things which the mind foreſees will follow from their own cauſes. Namely, that this moſt beautiful frame of animals is ſo various, and ſo exquiſitely fitted for its proper and diſtinct functions of every kind, and the offices and manner of life for which the animal is deſigned; that it is calculated according to laws more perfect than any human geometry; that the ends have been foreſeen in the eye, in the ear, and the hand, ſo that to theſe ends every thing is moſt evidently accommodated: it appears, therefore, certain to me, that no cauſe can be aſſigned for it below the infinite wiſdom of the Creator himſelf. Again, the more frequently, or the more minutely, we obſerve the long ſeries of increaſe through which the ſhapeleſs embryo is brought to the perfection neceſſary for animal life, ſo much the more certainly does it appear, that thoſe things which are obſerved in the more perfect fœtus have been preſent in the tender embryo, although the ſituation, figure and compoſition ſeem at firſt to have been exceedingly different from what they ſhow themſelves to be at laſt; for an unwearied and laborious patience has diſcovered the intermediate degrees by which the ſituation, figure, and ſymmetry, are inſenbly reformed. Even the tranſparency of the primary fœtus alone conceals many things which the colour added a little after does not generate, but renders conſpicuous to the eye. And it ſufficiently appears that thoſe parts which eminent anatomiſts have ſuppoſed in aftertimes to be generated, and to be added to the primeval ones, have been all cotemporary with the primeval parts, only ſmall, ſoft, and colourleſs.

DCCCLXXXVI. It is highly probable, that for a long time the latent embryo neither increaſes nor is agitated, except by a very gentle motion of the humours, which we may ſuppoſe to librate from the heart into the neighbouring arteries, and from theſe into the heart of the fœtus. But we may alſo ſuppoſe, that the ſtimulus of the male ſemen excites the heart of the fœtus to greater contractions, ſo that it inſenſibly evolves the complicated veſſels of the reſt of the body by the impulſe of the humours, and propagates the vital motion through all the canals of the little body of the animal; that it is more quick in ſome parts, and more ſlow in others; and that from thence it happens that ſome parts of the body of the animal ſeem to be produced very early, and others to ſupervene afterwards; and laſtly, that ſome do not ſhow themſelves until a long time after birth, as the veſicles of the ovaries, the veſſels of the male teſticles, the teeth, hairs of the beard, and horns of brute animals. In all animals, heat aſſiſts this evolution; in the more ſimple ones, whoſe veſſels are few, and leſs complicated in their various origins, it is the ſole inſtrument of bringing it to perfection[183].

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[183] How great difficulties, diſcordant opinions, and innumerable conjectures, prevail in the doctrine concerning animal generation, no perſon can be ignorant, who, after the immortal work of Haller, in which theſaurus we have every thing mentioned from the beginning of ſcience down to our times concerning the theory of generation, conſults the works of the lateſt authors of reputation, Needham, Buffon, Bonnetus, Wolf, which, we have good reaſon to apprehend,

DCCCLXXXVII. Of the objections which are uſually brought, ſome are not true; ſuch as the ſuppoſition of an excreſcence of a different ſtructure from the reſt of the body; others ſeem to belong to cauſes depending on ſome accident, ſuch as moſt kinds of monſters; ſome to the increaſe of ſome particular parts, occaſioned by the powers of the male ſeed; ſome to the cellular texture variouſly relaxed, as it ſeems to increaſe in the parts newly produced, or to be occaſioned by indurated juices. Although it is not eaſy to explain every thing mechanically, yet we ought to remember, that if indeed the new animal is truly, and ſhown by experience to be, preſent in the egg, thoſe difficulties which are moved cannot overturn ſuch things as have been truly demonſtrated, although perhaps ſome things may remain, to which, in ſo great an infancy of human knowledge, we cannot yet give a full anſwer.

DCCCLXXXVIII. When the human ovum is brought down into the uterus, we become more ſenſible of its change of ſhape after the interval of a few days. The ovum itſelf ſends out every where ſoft branchy flocculi from

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prehend, are not free of every difficulty, although they have been partly confirmed by the labours of prior authors, and partly increaſed by new reflections from Fabricius, Harvey, Graaf, Malphigius, Valiſner, &c. Nature ſhows great regularity in the production of animals and vegetables, though all are not generated in one and the ſame way: all plants do not originate from ſeeds, nor animals from eggs; but in any kingdom of natural bodies, ſome are produced in the moſt ſimple way, without the neceſſity of both ſexes, and from a particle, reſembling a whole individual, ariſes a new individual: but others are produced by means of proper organs, and by new generation. The excellent obſervations of Necker, Munchus, Koelrute, Helwig, Mont, Cort, about muſhrooms, moſſes, and other cryptogamic plants ſo called; Ellis's, Butner's, Bochadſch's, Pallas's, and Diequemare's obſervations about corals and other ſea bodies; De Geer, Bonnetus, Schroetes, Goetz, and Sinebier, about ſeveral animals; Spallanzani, Muller, Sauſſure, Terechofsky, and our own experiments, upon animalcula; Trembley, Roeſel, Reaumur, Schaffer, about polypi; and likewiſe Spallanzani, Shaeffer, Watel, and Murray, upon ſhells and ſnails; and Spallanzani's, and my own trials, upon lizards; all theſe I ſay, have convinced me, that our whole knowledge of generation conſiſts merely of phenomena, upon which it has as yet been impoſſible to raiſe a true and infallible ſyſtem.

from the ſuperficies of its membrane hitherto ſmooth, which adhere to and inoſculate with the exhaling and reſorbing flocculi of the uterus (DCCCXLIII.) This adheſion happens every where in the uterus; but chiefly in that thick part which is interpoſed between the tubes, and is called the *fundus uteri.* Thus the thin ſerous humour of the uterus, proceeding from its arterial villi, is received into the ſlender venous veſſels of the ovum, and nouriſhes it together with the fœtus. But before this adheſion, it is either nouriſhed by the matter it already contains, or elſe by ſuch juices as it abſorbs from the ſurrounding humours, if indeed there is any time when it does not adhere.

DCCCLXXXIX. At this time, in the ovum, there is a great proportion of a limpid watery liquor, which, like the white of an egg, hardens by the heat of fire, or a mixture with alcohol; and now the fœtus, for a long time inviſible, as I have never obſerved it before the 17th day, makes its appearance at firſt a ſhapeleſs maſs, conſiſting of mere mucus, and as yet ſeemingly of a cylindrical ſhape. When ſome diſtinction of parts is next to be ſeen, it has a very great head, a ſmall ſlender body, no limbs, fixed by a very broad flat navel to the obtuſe end of the ovum.

DCCCXC. From hence forward the fœtus continually increaſes as well as the ovum, but in an unequal proportion: for while the arterial ſerum is conveyed by more open paſſages into the ſmaller veſſels of the ovum, the fœtus itſelf grows the faſteſt; becauſe now the greateſt part of its nouriſhment ſeems to paſs through the very large umbilical vein. At the ſame time the ovum itſelf alſo grows, but leſs in proportion; and the waters, which it includes, gradually diminiſh from their firſt proportion, in reſpect of the bulk of the fœtus. The fleecy productions of the veſſels from the ovum are gradually ſpread over with a continued membrane, and only thoſe which ſprout out from the obtuſe end of the ovum take root, or increaſe ſo as to form a round circumſcribed placenta or cake.

DCCCXCI. Such is the appearance of the ovum, as we have here deſcribed it, commonly in the ſecond month; from which time it changes only by increaſing in bulk. That part of the ovum next the fundus uteri is commonly uppermoſt, making about a third of its whole ſurface, in form of a flat round diſh or plate; ſucculent, fibrous, full of protuberances, but throughout perfectly vaſcular; changing into other tubercles of the ſame kind, for the moſt part accurately, and often inſeparably, connected with the uppermoſt part of the uterus, remarkable for its large veſſels, of a thin cellular texture, collecting the veſſels every where, but chiefly in the circumference of the greateſt circle, as well the exhaling arteries anſwering to ſuch as come from the uterus into the veins of the placenta, as the arteries of the placenta opening into the large veins of the uterus. There, in the common ſurface of the uterus and placenta, a communication is made, by which the uterus ſends to the fœtus, firſt that white ſerous liquor not unlike milk, and laſtly, as it ſeems, red blood itſelf. This communication of the humours ſeems to be demonſtrated by the ſuppreſſion of the menſes in women with child, whoſe blood muſt be turned into another channel; from the loſs of blood which follows from a ſeparation of the placenta in a miſcarriage; and from the blood of the fœtus being exhauſted from an hemorrhagy in the mother; from hemorrhagies that enſue from the navel-ſtring, ſo as to kill the mother when the placenta has been left adhering to the uterus; and, laſtly, from the paſſage of water, quickſilver, tallow, or wax, injected from the uterine arteries of the mother into the veſſels of the placenta, as is confirmed by the moſt faithful obſervations. But that it is blood which is ſent into the fœtus, is evinced by the magnitude of the ſinuſes of the uterus and placenta; the diameter of the ſerpentine arteries of the uterus; the hemorrhagy that follows, even when the placenta is very ſlightly hurt; but eſpecially by the motion of the blood, which, in a fœtus deſtitute of a heart, could only be given to the humours of the fœtus by the blood of the mother[184].

DCCCXCII.

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[184] The manner in which the fœtus is nouriſhed after conception, labours under a like difficulty with the origin of conception itſelf. Of the two moſt noted conjectures which uſually explain the communication of the uterus with the placenta, reſorption, or the immediate anaſtomoſis of the blood-veſſels, the laſt has always had the moſt partiſans. I am ſorry that various arguments, ſufficiently weighty, prevent me from ſo eaſily embracing the ſame ſide; which arguments my celebrated pupils, Balthaſer and Moeller, have already mentioned, and which ſhall now be partly delivered by myſelf. They may be conveniently divided into two claſſes; the firſt contains the doubts of anaſtomoſis; the laſt, the arguments tending to prove it. In the firſt claſs it is denied,

1. Becauſe the young of birds, removed at a great diſtance from their mother, ſo that they cannot get any blood from her, prepare true blood from their own nouriſhment, the yolk and white.

2. Anaſtomoſis between veſſels of ſo great magnitude and importance, the abſtraction of which ſo large a hemorrhagy frequently follows, ought not to be formed and ſupported by veſſels ſo very ſmall and imperceptible to the naked eye, but by larger ones; the number of which, however, in the natural abſtraction of the ſecundines, we find neither in the uterus nor placenta to be great.

3. As often as I have taken the egg from the uterus of animals which have died at various periods of pregnancy, I always found in the uterus a liquor reſembling milk, rarely blood.

4. By the moſt ſucceſsful injections, made with all due care, once into the uterus of a pregnant woman who died in the ſeventh month of geſtation of a wound, ſeveral times into the wombs of mares, cows, goats, rabbits, dogs, and cats, &c. preparations of which I poſſeſs, I never could convey the ſmalleſt quantity of the moſt ſubtile liquor into the uterus from the veſſels of the cord, nor from the veſſels of the uterus into the placenta: the liquor entered only the cellular texture of the fungous chorion, and filled it with irregular particles.

5. I have ſometimes filled the recent ſecundines of women, and ſeveral brutes, that have come away ſpontaneouſly immediately after birth; but I never ſaw the mercury ruſhing forward, as we ſhould have obſerved in the rupture of anaſtomoſing veſſels, which nevertheleſs penetrates the moſt ſubtile veſſels.

6. I have met with a few dogs juſt before birth killed by cutting through the carotids; which being almoſt half alive, I have filled through the uterine veſſels with a very ſubtile liquor. The preparations which I poſſeſs are proofs of the moſt happy and ſucceſsful injection. However, I have done nothing more in theſe than to puſh the fluid and coloured matter into the cells of the fungous chorion; but there are not the ſmalleſt traces of its entering the veſſels of

DCCCXCII. The remaining part of the ovum, and likewiſe the ſurface of the placenta, are covered by an external

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of the placenta. As to the other ſide of the queſtion, the arguments there are not of leſs weight: for,

1. The ſuppreſſion of the menſes in pregnancy cannot ſo much prove it, ſince (*a*) ſeveral animals have no menſes; (*b*) they are not ſuppreſſed in all women; (*c*) the maſs of menſtrual blood ſuppreſſed after conception, amounting to twelve, ſixteen, or even twenty ounces, can in no ways be expended upon the ſmall maſs of embryo of the firſt or ſecond month, which, together with the ſecundines, weighs ſcarce an ounce.

2. Thoſe great and dangerous hemorrhagies which happen after the abſtraction of the human placenta, excite no ſmall ſuſpicion of an immediate anaſtomoſis. But (*a*) the flow of blood does not happen in all with the ſame force; but is ſometimes ſeveral pounds, ſometimes a few ounces and drachms: (*b*) and the ſame flux is the more gentle the more carefully the abſtraction has been performed, and *vice verſa;* and in very profuſe fluxes the uterus is, for the moſt part, more or leſs injured. (*c*) I have ſeen abortions of two or three months attended with a very ſmall profuſion; and I now remember five in which ſcarce an ounce was loſt. (*d*) In the birth of brutes, ſo large effuſions never happen, or do not laſt ſo long.

3. It would truly be a weighty argument, which would eaſily determine me to embrace the doctrine of anaſtomoſis, if I could reconcile it with my own obſervations, that the fœtus is deprived of a great part of its blood if the mother has died of an hemorrhagy. But I have ſeen (*a*) a human fœtus whoſe mother had died in the ſeventh month of geſtation of a very bloody wound, and had ſuffered a great effuſion, which had loſt no blood out of the heart nor larger veſſels; nay, not even in the placenta itſelf did the ſtate of the blood-veſſels exhibit any mark of hemorrhagy. (*b*) Next, I have killed pregnant dogs and cats, juſt upon the time of birth, by cutting the carotids; I have examined the uterus of cows and mares, killed by means of a very large wound of the heart, without finding in any of them either the ova or fœtus ſhowing the leaſt defect of blood.

4. That mothers may ſuffer fatal hemorrhagies from cutting and not tying the cord, neither my own obſervations, nor thoſe of Roederer, will allow; and no perſon at preſent directs midwives to begin the tying of the cord towards the placenta.

5. The venous ſinuſes, ſo called, in the uterus, except the cellular ſubſtance of the fungous chorion, ſeem to afford no proof. I have obſerved ſuch ſinuſes, ſo called, in the uterus, if a very great part of the ſpongy chorion has cohered to the uterus. I have perceived them on the placenta, if it had adhered to it. The blood detained here does not abſolutely demonſtrate the continuation of veſſels: it only ſhows, that a certain ſtore is prepared, from which the abſorbent

external villous and fleecy membrane, full of pores and ſmall veſſels, of a reticular fabric, eaſily lacerable, ſo as to reſemble a fine placenta, and is called the *chorion*. But even this is connected to the flocculent ſurface of the uterus, which is very like to itſelf, but ſofter, by veſſels ſmaller than thoſe of the placenta, but manifeſtly inoſculated from the chorion into the veſſels of the uterus.

DCCCXCIII. Under the chorion lies a continuous, white, opaque, and firm membrane, not vaſcular, which does not cover the part of the placenta turned towards the uterus, but is concave, and turned to the fœtus. It coheres by a cellular texture both to the chorion and amnios. The moſt ſimple name we can give it, is the *middle* membrane[185].

DCCCXCIV. The innermoſt coat of the fœtus, which is called *amnios*, is a watery pellucid membrane, very rarely ſpread with any conſpicuous veſſels, which yet I have obſerved in an human ſubject; extremely ſmooth, and in all parts alike; alſo extended under the placenta with the former, the ſurface of which is every way in contact with the waters. If there are more fœtuſes than one, either in man or beaſt, each of them has their proper amnios.

DCCCXCV.

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bent veſſels of the placenta may receive their nouriſhing matter, which contains a mixture of the blood itſelf tranſmitted through the increaſing veins, whoſe reſiduum is reabſorbed by the veins of the uterus, and at length mixed with the blood. Does not the like happen in other ſpongy parts?

6. As to examples of fœtuſes wanting the heart, whoſe circulation therefore ſhould have depended upon the mother alone, although I am not ſo certain of the truth of them, I could oppoſe as many other obſervations of a ſimilar monſtrous mechaniſm in birds.

[185] There are three real tunics of the human ovum, any of which may be ſeparated into new lamella. The outermoſt, which ſhould be called the fungous or ſpongy chorion, is almoſt the ſame ſubſtance with the acetabula in the ſecundines of brutes, that part, to wit, proper partly to the uterus, partly to the placenta, which has been excellently deſcribed by Cooper and Sandifort; but moſt elegantly delineated by the famous Dr Hunter. The middle one may be called *læve chorium*, and the innermoſt one is known by the name of *amnium*.

DCCCXCV. The nouriſhment of the fœtus, from the beginning to the end of the conception, is without doubt conveyed to it through the *umbilical vein.* This gathers its roots from the exhaling veſſels of the uterus (DCCCLIV.), and it has manifeſt communications by ſome roots with the umbilical artery, from whence it in part riſes, and, meeting together in a large trunk, is twiſted in a circular manner through a number of folds to a ſufficient length, that may allow of a free motion; and in this courſe it is ſurrounded with a cellular ſubſtance full of mucus, diſtinguiſhed by three partitions, and the membrane which is continued to the amnios, but known by the name of the *umbilical rope;* and after forming ſome protuberances, it enters through the navel, in an arch made by a parting of the ſkin and abdominal muſcles, and goes on through a proper ſinus of the liver (DCXCII.), into which the ſmaller portion of the blood that it conveys is poured through the ſlender ductus venoſus into the vena cava ſeated in the poſterior foſſa of the liver: but the greater part of its blood goes through the large hepatic branches, which conſtantly ariſe from its ſulcus, and remain even in the adult (DCXCV.); but it goes thence to the heart by the continuous branches of the vena cava (DCXCVII.) The ſinus or left branch of the vena portarum itſelf is a part of the umbilical vein, and its branches bring the blood from the placenta to the cava, while the right branch alone carries the meſenteric and ſplenic blood through the liver.

DCCCXCVI. But this is not all the uſe of the placenta; for the fœtus ſends great part of its blood again into the ſubſtance thereof, by two large *umbilical arteries*, which are continued on in the direction of the aorta; and after giving ſome ſlender twigs to the femorals, with ſtill ſmaller arteries into the pelvis, they aſcend reflected back with the bladder on each ſide of it, ſurrounded with the cellular plate of the peritonæum, with ſome fibres ſpreading to them from the bladder and urachus, in which manner they proceed on the outſide of the peritonæum into the cord at the navel, in which paſſing alternately in a ſtraight and contorted courſe, they form various twiſtings or windings, ſomewhat ſharper than thoſe of the vein which they play around; in which manner they at laſt arrive at the placenta, whoſe ſubſtance is entirely made up of their branches, in conjunction with thoſe of their correſponding veins, and a ſlippery cellular ſubſtance following both veſſels; ſo that the kernels themſelves, that are conſpicuous in the placenta, are convolutions of thoſe veſſels. By theſe branches the blood ſeems to paſs out through the minute arteries of the placenta into the bibulous veins of the maternal uterus, that after undergoing the action of the lungs by the mother's reſpiration, it may return again in an improved ſtate to the fœtus: for what other reaſon can be aſſigned for ſuch large arteries, which carry off above a third part of the blood of the fœtus?

DCCCXCVII. But it will perhaps be demanded, Whether the fœtus is not nouriſhed by the mouth likewiſe? Whether it does not drink of the lymphatic liquor contained in the cavity of the amnios, which is coagulable, unleſs putrefied, and in the middle of which the fœtus ſwims, and whoſe origin is not ſufficiently known? Whether this opinion is not in ſome meaſure confirmed by the open mouth of the fœtus, and the analogy of chickens, which are under a neceſſity of being nouriſhed from the contents of the egg only? to which add the abſence of a navel-ſtring in ſome fœtuſes; the quantity of meconium filling the large, and part of the ſmall, inteſtines; the ſimilitude of the liquor found in the cavity of the ſtomach to that which fills the amnios; the proportionable decreaſe of the liquor amnii, as the fœtus enlarges; the glutinous threads which are found continued from the amnios, through the mouth and gula, into the ſtomach of the fœtus; the true feces found in the ſtomach of the fœtus of quadrupeds; the open mouth of the fœtus, which we have certainly obſerved; the gaping of a chicken ſwimming in this liquor, and its attempts as it were to drink it up? Again, what are the fountains or ſprings from whence this lymph of the amnios flows? whether it tranſudes thro' the inviſible veſſels of the amnios, or through certain pores from the ſucculent chorion, which is itſelf ſupplied from the uterus? It muſt be confeſſed, that theſe inquiries labour under obſcurities on all ſides; notwithſtanding which, there ſeems more probability for them than otherwiſe, ſince the liquor is of a nutritious kind, at leaſt in the firſt beginnings of the fœtus, and derived from the uterus.

DCCCXCVIII. All the excremental feces, which are collected in the fœtus during the whole time of its reſidence in the womb, amount to no great quantity, as they are the remains of ſuch thin nutritious juices, percolated through the ſmalleſt veſſels of the uterus. I frequently obſerve, that the bladder is almoſt empty in the fœtus. However, there is generally ſome quantity of urine, collected in a very long conical bladder. But in the cavity of the inteſtines, there is collected together a large quantity of a dark green pulp, which may poſſibly be the remains of the exhaling juices[186], like the feculent remains, which are ſometimes left in the other cavities of the body that are filled with exhaling juices, and ſuch as I have ſometimes obſerved even in the vaginal coat of the teſticle.

DCCCXCIX. It may then be demanded, whether there is any allantois? ſince it is certain that there paſſes out from the top of the bladder a duct called the *urachus*, which is a tender canal, firſt broad, covered by the longitudinal fibres of the bladder as with a capſule; and afterwards, when thoſe fibres have departed from each other, it is continued thin, but hollow, for a conſiderable way over the umbilical cord, yet ſo that it vaniſhes in the cord itſelf. Whether this, although it be not yet evident in the human ſpecies, is not confirmed by the analogy of brute animals, which have

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[186] The greateſt part of the meconium unqueſtionably ariſes from the bile, which is very plentifully ſecreted by the fœtus, the magnitude of the liver being ſo great.

both an urachus and an allantois? But as for any proper receptacle continuous with the hollow urachus, it either has not yet been obſerved with ſufficient certainty, or elſe the experiment has not been often enough repeated, to render the opinion general in the human ſpecies; and thoſe eminent anatomiſts who have obſerved a fourth kind of veſſel to be continued along the umbilical rope into its proper veſicle, will not allow that veſſel to be called the urachus, and very lately have referred it to the omphalo-meſenteric genus[187]; and in the human fœtus, the urine is ſeparated in a very ſmall quantity: but it perhaps may be no improbable conjecture, that ſome portion of the urine is conveyed to a certain extent into the funiculus umbilicalis, and there is transfuſed into the ſpungy cellular fabric that ſurrounds it; and therefore, that, of all animals, man has the longeſt umbilical cord, becauſe he alone has no allantois. But then this can take up but a ſmall ſpace, terminating in the funis, and hardly ever ſeems to reach as far as the placenta. Somtimes, even in an adult perſon, this open duct has brought the urine to the navel.

DCCCC. In the mean time, the fœtus continues to advance in growth; the limbs by degrees ſprout from the trunk, under the form of tubercles; and the other outworks of the human fabricature are by degrees beautifully finiſhed, and added to the reſt; in a manner not here to be at large deſcribed, as indeed it has not been as yet by anatomiſts in general; of which, however, we muſt premiſe ſome compendium.

DCCCCI. The embryo which we firſt obſerved in the uterus of the mother was a gelatinous matter, having ſcarce any proper ſhape, and of which one part could not be diſtinguiſhed from another. There was, however, in that gluten a heart, which was the cauſe of life and motion; there were veſſels which generated the humour of the amnios; there were therefore veſſels of the umbilicus and yolk, the little trunks of which, being received from the fœtus, are at that time very large, ſeeing they have lately begun to be obſerved. There was both a head and ſpinal column, both parts very large, and larger in proportion to the reſt than ever. There were likewiſe, without doubt, all the reſt of the viſcera, but pellucid and of a mucous nature; for which reaſon, they may be obſerved ſome days ſooner than can be hoped for from nature alone, if you render them opaque.

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[187] Since I firſt made a drawing in my anatomical deſcriptions of the embryo, after Albinus and Bœhmer, concerning the bladder reſembling the allantois, which Hunter and Sandifort have confirmed by an elegant figure, I have twice had an opportunity of ſeeing the ſame with a ſimilar filament. I filled another fœtus with wax; and that filament which might impoſe upon us for the urachus was likewiſe filled: the artery certainly ran from the veſſels of the omentum to the cord, and was diſtributed in very ſmall branches through the cellular texture of the rope and upon the bladder.

DCCCCII. But in the whole fœtus, an immenſe quantity of water is mixed together with a very little earth, as the very cellular texture ſurrounds it in a ſtate between fluid and ſolid; ſeeing large drops of water are interpoſed betwixt the remote elements of the ſolid parts.

DCCCCIII. In birds there is added to this the vivifying gluten or white of the egg, which is of the nature of lymph; and the yolk, which is of an oily nature: in man, ſomething of a milky nature, not altogether unlike the yolk of an egg, and the coagulable lymph. That the blood is perfected from the fat by the proper powers of the fœtus, we are perſuaded from the example of birds. From it are inſenſibly prepared all the other humours; but all of them at firſt mild, void of taſte, colour and ſmell, and of a glutinous nature. The proper nature of every one of them approaches to that of ſerum; but ſome of them are not produced till many years after birth, for inſtance the ſemen.

DCCCCIV. The firm parts, even in a grown perſon, make much the ſmalleſt portion even of the harder parts of the human body; in the fœtus they differ from the fluids, by a ſomewhat greater degree of coheſion;

as yet, however, they are like a gluten, at firſt fluid, and afterwards more conſiſtent. In theſe the fibres which we could not diſtinguiſh in the primeval embryo are by degrees produced; the gluten, as it would ſeem, being ſhaken between the neighbouring veſſels, part of the water expreſſed, and the terreſtrial parts attracting one another. Theſe fibres variouſly comprehend one another, and form a cellular texture, even in diſeaſes, and intercept little ſpaces, in which there is a kind of humour. From this cellular ſubſtance are formed the membranes and veſſels, and almoſt the whole body.

DCCCCV. The veſſels are the oldeſt parts of the body, and are prepared in the firſt delineation of the embryo. What firſt appears in an egg during the time of incubation, having any diſtinct form, are venous circles: but theſe veins fabricate the arteries, by which they both receive their juice, and the motion of that juice. They are not generated mechanically from an obſtacle, as the arterial blood is found at that time. At firſt the trunks of the veins are conſpicuous, afterwards the branches which convey the humours to the trunks. If they were produced from the arteries reflected, the branches would firſt be ſeen, and the trunks formed in the laſt place. Neither could the arterial blood, driven back by an obſtacle, form thoſe moſt beautiful circles, and bring back the veſſels into the heart. It would rather flow irregularly through the cellular texture. And the primeval heart would ſoon loſe its life, unleſs as much of the humours returned to the heart as was ſufficient to keep up its pulſations.

DCCCCVI. There are, therefore, in the primeval fœtus, ſuch as we firſt obſerve it, ſome things more perfect and conſpicuous; others involved, inviſible, and very ſmall. The heart is the moſt perfect; it is the only moveable and irritable part; although it is in many reſpects different from what it is in an adult perſon. The brain is large and fluid; the veſſels formed which appear in the back next to the heart. The viſcera, muſcles, nerves, and limbs, are not yet to be ſeen;

the bones themſelves are preſent, of which the firſt appearance is a mucus, as are the veſſels of the reſt of the body. The other portion is that of the abdomen, the umbilical capſule of which is an immenſe hernia.

DCCCCVII. To this embryo is ſuperadded motion, in man almoſt of the heart alone; as alſo in birds, whoſe formation does not take place without heat rather greater than that of the human body: yet, without the heart, heat deſtroys, inſtead of forming the fœtus. It is the largeſt in proportion to the reſt in theſe beginnings; afterwards its proportion to the other parts of the body grows gradually leſs and leſs. Its pulſations are alſo at this time the moſt frequent, and in the ſofteſt fœtus the moſt powerful for impelling the humours, and diſtending and producing the veſſels.

DCCCCVIII. To the force of the heart is oppoſed what is of ſervice however in forming the fœtus, namely, the viſcidity of the vital humours which collect the earthy elements. There is therefore in the embryo both an impelling force, which increaſes the parts longitudinally; and a reſiſting force, which moderates the increaſe, and increaſes the lateral preſſure, and thus the diſtention. By the force of the heart all the arteries, but for eaſineſs of expreſſion we ſhall ſay only one artery, which repreſents all the reſt, with all its ſurrounding cellular texture, is lengthened out; its folds are ſtretched out, and the ſame artery is dilated. And the blood by its lateral preſſure makes an effort againſt the almoſt blind branches of the arteries, fills and evolves them, and ſets them off at more obtuſe angles: thus are produced ſpaces which make very little reſiſtance, in which the gluten is depoſited. In the very ſubſtance of the artery itſelf, while it is every where dilated, between its imaginable ſolid threads are prepared little reticulated ſpaces like a ſtretched-out net, which are equally fit for receiving humours. The largeſt of theſe are formed round the heart and in the head, whither the impulſe of the heart drives the humours in a ſtraight direction, and in the placenta: the leſſer ones are in the inferior part of the body, from which the umbilical arteries ſubtract the greateſt part of the blood.

DCCCCIX. The fœtus increaſes very quickly, as is moſt evident in the example of a chicken, whoſe length the twenty-ſecond day is to its length the firſt day at leaſt as 1,000,000 to 1; and the whole increaſe of bulk in the bird during the remainder of its life does not exceed the fifth part of the increaſe of the egg the firſt day. For the fœtus has a larger and more irritable heart, veſſels larger in proportion, and likewiſe more numerous and relaxed, and the ſolid parts are mucous and diſtenſible. The breaſt is later of coming to perfection, ſurrounded with membranes ſo ſoft, that they cannot be ſeen.

DCCCCX. The embryo does not only increaſe in bulk, but is ſo remarkably altered in ſhape, that it comes forth into the light totally diſſimilar from any thing that could be obſerved in it at its firſt formation. And firſt it is probable, that the articulations of the limbs are produced from the elongated arteries, that they are laterally knit together by a certain gluten, ſeparately evolved, and at firſt that they ſprout out very ſhort, but afterwards increaſe by inſenſible degrees, and appear divided into diſtinct articulations, as the wings of a bat are formed from an open vaſcular net-work. Thus likewiſe the right ventricle of the heart is expanded by the blood coming to it in greater quantity; and, being increaſed by degrees, equals the left.

DCCCCXI. On the other hand, the cellular texture, from its glutinous aqueous nature, by which earthy particles are continually brought to it, becomes inſenſibly harder; by a gentle attraction contracts its parts, which were before ſtraight, into various flexures; and ties the auricles to the heart, from which they were as yet at a diſtance. So the muſcles draw out proceſſes from the bones by their continual pulling, and open ſmall cavities into large cells: the ſame likewiſe incurvate the bones, and variouſly figure them.

DCCCCXII. Preſſure can do a great deal: to it we muſt attribute the deſcent of the teſticles into the ſcrotum, after the irritable force of the abdominal muſcles has taken place: to this alſo we muſt aſcribe the repulſion of the heart into the breaſt, when the integuments of the breaſt are larger: to it we are to aſcribe the length of the breaſt and the ſhortneſs of the abdomen, and the ſmaller ſize of the viſcera of the latter; becauſe the air received into the lungs dilates the cavity of the thorax. But even the bones are variouſly hollowed out by the preſſure of the muſcles, blood-veſſels, and even of the very ſoft brain itſelf; and by the ſame means fleſh is changed into a tendinous ſubſtance.

DCCCCXIII. The power of derivation brings the blood into the pelvis and lower extremities from the cloſed umbilical arteries: the ſame, when the foramen ovale is contracted by the auricles drawn towards the heart, evolves the right ventricle of the heart: when the veſſels of the yolk have taken up the whole length of the egg, and can receive no farther elongation, it dilates the umbilical arteries of the chick, and produces a new membrane with incredible celerity. On the other hand, but by the ſame power, after the blood has got an eaſy paſſage through ſome veſſels of any part, the other parts which do not afford a like eaſy paſſage increaſe the leſs. The head grows leſs after the lower limbs have begun to increaſe in bulk.

DCCCCXIV. A membrane may be formed from a humour of which the thinneſt part is exhaled, as we have an example in the epidermis: from the ſame may be formed a cartilage as happens in the bones, or even a bone itſelf, or ſomething of a ſtony nature, which is very frequent in the teſticles of aquatic animals. The bones at firſt are ſoft, and of a mucous nature; then they become of the conſiſtence of jelly; this afterwards becomes a cartilage; without any change made on the parts, as far as can be obſerved.

DCCCCXV. A cartilage, however, is not afterwards ſecretly changed into a bone. That never happens, unleſs lines and furrows have at firſt run along the cartilage:

tilage: nay, the red blood has made a paſſage to itſelf through the veſſels of the bones; but theſe veſſels manifeſtly come from the nutritious trunks in the interior parts of the bone, and ſtrike as it were in right lines on the cartilaginous extremity of the body of the bone, which they remove farther and farther from its middle. Round theſe veſſels is formed a cellular texture and laminæ, which ſeem to preſs the veſſels themſelves towards the medullary tube. Laſtly, in the epiphyſis, which both remains much longer cartilaginous, and denies entrance to the blood, the red veſſels penetrate through the cruſt which covers the extremity, as well as the others which come from the exterior veſſels of the limbs. Thus alſo in the epiphyſis is produced a red nucleus of a vaſcular texture, which, being gradually increaſed by veſſels ſent out from its ſurface, changes the reſt of the cartilage into a bony nature.

DCCCCXVI. In theſe long bones it ſeems evident, that the increaſe is owing to the arteries elongated by the force of the heart, and gradually extended to the extremities of the bones: but that the hardneſs is owing to groſs particles at laſt depoſited in the cartilage when its veſſels admit the red blood. But even a bony callus never becomes ſound till the newly formed red veſſels have penetrated its ſubſtance.

DCCCXVII. The flat bones originate from ſomething of a membranaceous nature. Over this the fibres ſpread themſelves, at firſt in a looſe net-work, but afterwards they become more denſe, having the membrane for their baſis; the pores and clefts between theſe fibres being gradually contracted and filled with a bony juice, at laſt perfect the nature of the bones.

DCCCCXVIII. That a heavy bony juice, conſiſting of groſſer particles, is depoſited between the primeval fibres, is proved by the phenomena of the growing callus, which exſudes in ſmall drops, not from the perioſteum, but from the inmoſt ſubſtance of the bone, and is hardened by degrees. But even a chymical analyſis extracts that gluten from the bones; and in an anchyloſis it appears poured round the joint in a fluid; and manifeſtly fills up the chinks of the bones and intervals of the ſutures. It contains groſs earthy particles, which have been diſcovered by various experiments; and the juice of madder which adheres to it, manifeſtly diſtinguiſhes it by its colour.

DCCCCXIX. The perioſteum covers the bones, as a membrane does any of the viſcera; and from it cellular productions follow the interior veſſels of the bones: but, in the perioſteum, there are neither ſtraight fibres, nor an appearance of alveoli or laminæ, nor red veſſels, while the bone grows hard in the egg; nor does the perioſteum at all adhere to the bone, except in the epiphyſis, when it has aſſumed a bony nature in the middle; and it is thinneſt when the bone is in a cartilaginous ſtate, but every where complete. In the flat bones it every where affords a baſis for the bony fibres.

DCCCCXX. Therefore the head is large, every where membranaceous, in a few places cartilaginous on theſe firſt days of geſtation, with a mouth deeply cut, and long jaws. In the fœtus come to maturity, there are alſo rudiments of the teeth, which have a great deal of membrane as an appendage: the brain, at firſt fluid, and always ſoft, is itſelf very large, with large nerves: the eyes are big, and the pupil ſhut by a membrane: the breaſt is very ſhort, but capable of extenſion, on account of a great quantity of cartilage: the abdomen is large, ſurrounded with membranes, with a very large liver: the bile is innocent and mucous: the inteſtines are at laſt irritable, and full of ſoft, green, excrement, when the fœtus has now arrived at its ſtate of maturity: the kidneys are divided into lobes, are large, and have very big capſules: the pelvis is very ſmall, ſo that the bladder, ovaries, and tubes, project from it: the genital ſyſtem is denſe, not yet evolved, nor preparing its juices: all the glands are large, particularly the conglobate ones, and full of a ſerous juice: the ſkin is at firſt pellucid, then gelatinous, and at laſt covered with a ſoft cuticle and ſebaceous ointment: the fat is firſt gelatinous, and then grumous: the tendons ſoft, ſucculent, and not yet ſhining.

DCCCCXXI. There is a great difference betwixt the circulation of the blood in the fœtus and in the adult: that this may be underſtood, it is neceſſary to deſcribe the organs by which it is performed. The firſt is the *thymus*, a ſoft looſe gland, conſiſting of very many lobes, collected into two large upper horns, and two inferior ſhorter ones, which are however joined together by a great deal of long and lax cellular texture: this gland is large in the fœtus, and occupies a great part of the breaſt: it is ſeated in the cavity of the mediaſtinum, and part of the neck; and is wholly filled in its very inmoſt ſtructure with a white ſerous liquor, which cannot be diſcovered without wounding it. This gland, in an adult, being continually leſſened by the increaſe of the lungs, and by the aorta now become larger, gradually diſappears. What is the uſe of this gland or its liquid, we are altogether ignorant; but even all the other glands, eſpecially the conglobate ones, are larger in the fœtus than the adult, as we have juſt now obſerved.

DCCCCXXII. The cavity of the breaſt is ſhort in the fœtus, and greatly depreſſed by the enormous bulk of the liver; the lungs are ſmall in proportion to the heart, and ſo ſolid as to ſink in water, if they are every way excluded from taking the atmoſphere into their ſpungy ſubſtance, in making the experiment. Since therefore the like quantity of blood (CCXCII, CCXCVII.) which paſſes the lungs by reſpiration in adults, cannot be tranſmitted through the unactive lungs of the fœtus, who has no reſpiration, there are other ways prepared in the fœtus, by which the greater part of the blood can paſs directly into the aorta, from the lower cava and umbilical vein, without entering the lungs. In the primeval fœtus there is no right ventricle of the heart; and therefore there is ſuch a large opening of the right auricle into the left, that all the blood which comes by the vena cava immediately paſſes into the aorta, a very ſmall quantity excepted, which goes to the inconſiderable and inconſpicuous lungs. Afterwards in the fœtus, now grown bigger, the lungs are indeed larger, and the paſſage from the right part of the auricle into the left is narrower, ſeeing the auricular canal is now taken into the heart, and the auricles themſelves are become much ſhorter. But yet the ſeptum betwixt the right and left auricle, conjoining them together, is perforated with a broad oval foramen; through which the blood coming from the abdomen, and a little directed or repelled by the valvular ſides of the right auricle (LXXXVIII.), flows in a full ſtream into the cavity of the left auricle. But it is by degrees that the membranes of each ſinus depart from each other, upward and backward, above the oval foramen into the pulmonary ſinus, where they are connected on each ſide above, by ſeveral orders of fibres, which below are palmated or like fingers, ſo as to cloſe up at firſt a ſmall part, and afterwards a greater part, of this foramen, ſo as to leave only a ſmall oval portion of it at liberty; which lies free betwixt the round margin of the ſaid oval foramen and the increaſing valve, making in the mature fœtus about a fifteenth part of the area or capacity of the mouth of the vena cava.

DCCCCXXIII. That the blood takes this courſe in the fœtus, and that it does not on the contrary flow from the ſinus of the left to that of the right auricle, is evident, from all manner of experiments and obſervation[188]. For, firſt, the column of blood in the right ſinus, is of all the largeſt; and, as it is the returning one from the whole body, cannot be exceeded by any other: but the left auricle has ſo much leſs blood in proportion than that of the right, inſomuch as part of it flows throw the duct or canalis arterioſus into the aorta, whence its contents will be much leſs than that of the right auricle: moreover, the valve of the oval foramen, in a mature fœtus, is ſo large, and placed ſo much to the left of the muſcular arch or iſtmus (DCCCCXXII), that when it is impelled by the blood from the left ſide, the valve, like a palate or ſhutter, cloſes up the foramen; but being impelled from the right ſide, it readily gives way ſo as eaſily to tranſmit either blood or flatus, but it will retain even flatus itſelf when injected from the right, nor will it ſuffer it to paſs back again to the right ſide.

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[188] Contrary to this ancient opinion of Galen and Harvey, which almoſt all the moderns, except Mery and Winſlow, have adopted, Mr Wolf has raiſed great doubts; and, as he goes upon diſſection, has ſubſtituded an ingenious and not improbable opinion. When he found that there was one foramen ovale in the right ſide formed by Vieuſſens's arch and Euſtachius's valve, and another in the left ſide formed by the ſame arch and foramen ovale, theſe ſinuſes in this way never could communicate. He therefore found, that the inferior vena cava, which opened both into the right ſinus and into the left, and poured a part of its blood into each ſinus, the valve of the foramen ovale being diſſected, was interpoſed between the ſinuſes, the left more

DCCCCXXIV. Moreover, there is but a ſmall portion of the ſame blood, which firſt entered the right auricle and ventricle of the heart, that takes its courſe through the lungs: for the pulmonary artery, being in the fœtus much larger than the aorta, is directly continued into the ductus arterioſus; which is larger than the light of both the pulmonary branches together, and greatly larger than the opening of the foramen ovale, and enters that part of the aorta which comes firſt in contact with the ſpine, under its left ſubclavian branch: by which means it transfers more than half the blood to the deſcending aorta, which muſt otherwiſe have paſſed through the left auricle and ventricle into the aſcending branches of the aorta; and this is the reaſon why the aorta in the fœtus is ſo ſmall at its coming out from the heart. By this mechaniſm an overcharge of blood is turned off from the lungs, by directing a great part of that

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more than the right, which he obſerved in heifers ſomewhat more accurately than in man. That portion of blood, therefore, which penetrates through the orifice of the inferior vena cava into the right ſinus, ſtraightway paſſes with the blood of the ſuperior vena cava into the right ventricle: But that portion of the blood which runs through the orifice of the inferior vena cava into the left ſinus, without touching the lungs, goes into the left ventricle with the blood of the pulmonary veins.

that fluid in a ſtraight courſe to the umbilical arteries, and the powers of both ſides of the heart are united in propelling the blood.

DCCCCXXV. Thoſe who have aſſerted that the fœtus reſpires in the uterus, having made very few experiments, have neglected that moſt eaſy one which is made by water, in which the fœtus will ſwim; and likewiſe by the lungs, which in a fœtus are conſtantly heavy, and ſink in water: laſtly, they do not attend to the evident ſhortneſs of the breaſt, and ſmallneſs of the lungs. Whether or not it can take in air through the vagina of the mother, is very difficult to be determined: and I ſuſpect it to be poſſible in a certain ſituation, that a well-grown fœtus, which is not too much compreſſed, may ſometimes draw in air, while it ſticks by a part of its body, between the parts of its mother.

DCCCCXXVI. As the fœtus grows larger, ſo the uterus increaſes proportionably; the ſerpentine arteries of which it is compoſed being extended by the impelled blood, and ſtretched into a more direct courſe; while the veins having their trunks compreſſed by the great bulk of the uterus, and being unable to return the blood, ſwell out into immenſe ſinuſes; and laſtly, from the menſtrual blood retained in the uterus, and not yet quite ſpent on the fœtus. Thus its thickneſs continues the ſame, becauſe the greater quantity of blood and dilatation of the arteries and veins make up for the extenuation of its ſolid parts. But more eſpecially the fundus, or upper part of the womb, increaſes beyond the reſt; ſo that, by dilating the above tubes, theſe laſt ſeem thus to deſcend from the middle of the uterus, which now by degrees goes out of the pelvis, even as high as the colon and ſtomach itſelf, ſo as to compaſs all the abdominal viſera, more eſpecially the bladder and rectum. The os uteri in the firſt months of geſtation is drawn upwards with the uterus itſelf, and recedes from the entrance of the vagina: after the third month, however, it again deſcends, and ſtretches into the vagina[189]. The ſame becoming perpetually ſhorter, projects upon the cloſe extremity of the vagina: it is, however, conſtantly tender; and, from that cartilaginous hardneſs which is obſerved in the virgin womb, is relaxed into a mucous ſoftneſs. It is never perfectly cloſed or ſhut together, but only ſtopped up and defended from the air by thick mucus from the ſinuſes, and perhaps from the veſicles which are ſeated in the cervix uteri. Moreover, the cervix or neck of the womb itſelf, which has long remained unchanged during the laſt months of geſtation becomes likewiſe ſhort, and forms a broad flat opening, of no length; which, towards the time of delivery, is always more or leſs relaxed and gaping. As theſe matters advance, the fœtus, which in the firſt months had no certain ſituation, being now grown to a conſiderable bulk, is, about the middle of the time of geſtation, folded together into a globe, in ſuch a manner that the head lies betwixt the knees; and being the heavier part, it ſubſides by degrees more and more into the pelvis towards the cervix uteri.

DCCCCXXVII. The various complaints in the uterus are now increaſed to the higheſt degree, being diſtended by the great quantity of blood retained in it; for nothing is more diſagreeable to a human creature than a violent tenſion, unleſs it is done very gradually. From the head of the fœtus ſinking down into the pelvis, the rectum, bladder, and that part of the uterus next the neck, and which is the moſt ſenſible, are preſſed, and become painful: the fœtus, having received its full increaſe of bulk, diſtends the uterus every way; and that with the greater uneaſineſs, becauſe, the waters being now taken away, the limbs which are fully formed, and the head, preſs much more vehemently on the uterus. It is thought alſo that the placenta itſelf, now very large, diſtracts the internal and naked ſurface of the uterus. From theſe cauſes ariſe at firſt ſlight endeavours of the uterus to free itſelf; and at laſt, when theſe cauſes are now got to their utmoſt height, ſuch an uneaſy ſenſation is occaſioned by the impacted head of the fœtus as ariſes from a collection of feces in the rectum; by which pain, therefore, the mother is conſtrained to attempt the birth of the child. The time of delivery comes on after the expiration of nine ſolar months, and is kept pretty exactly in every ſpecies of animals, although by ſome cauſes it may be accelerated or retarded for ſome weeks, according to the nature of theſe cauſes, whoſe power, however, we muſt not extend too far.

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[189] The aſcent of the uterus is continued for almoſt four months and a half, ſo that it is out of reach of the finger. In the beginning of the ſixth month it again begins to fall, and may be more eaſily reached by the finge

DCCCCXXVIII. The teneſmus thus increaſing till it is no longer tolerable, the mother uſes all her efforts by very deep inſpirations, which preſs downwards the uterus and viſcera of the abdomen (DCCLVI.); and at the ſame time the womb itſelf, by its contractile vital force, conſtringes itſelf ſo powerfully about the fœtus, as ſometimes to exclude it, without further efforts from the mother. The difficulties of the birth, however, are evidently overcome principally by the efforts of the mother, while the mouth of the uterus, now very ſoft, ſuffers itſelf to be diſtended by the head of the fœtus. Now the amnios, filled with the water, is firſt protruded vertically, before the head of the fœtus, ſo as to dilate the os internum uteri; in which, the membranes being by degrees extenuated and dilated, eaſily break, and pour out their waters, which lubricate the paſſages, and relax all the parts of the vagina. The naked head of the fœtus now preſents naturally with the face to the os ſacrum, directed that way by its weight: and being urged forward, like a wedge or cone, it further dilates the os uteri; till at length, by the more powerful efforts of the mother, which often looſen the bones of the pubes in young women, the head is thruſt out through the dilatable vagina, with intolerable pain to the mother, and an univerſal tremor of body; and if none of the bones of the pelvis happen to preſs unequally, the infant eaſily advances, and is delivered into the world. This happens difficultly even in quadrupeds; but moſt of all in the human race, whoſe fœtus has the largeſt head in proportion to its body.

DCCCCXXIX. It is natural for women to have but one child at a birth, which law they have in common with all the larger animals, unleſs they are of the carnivorous kind. Frequently, however, they have two[190], more rarely three, and ſcarce ever five. It is not to be doubted, however, that a ſecond fœtus may be conceived while the firſt remains in the uterus; ſeeing women have frequently born children, when a hard and oſſified fœtus had been for a long time retained in their uterus.

DCCCCXXX. The placenta of the fœtus, connected with the fundus uteri (DCCCLXXXVIII.), is, in the next place, ſeparated from the womb, without much difficultly in a mature birth, partly by the weaker throes of the mother, and partly by the extracting force of the deliverer; by which the fleecy or villous ſurface of the placenta being withdrawn from that of the womb, is immediately followed with a conſiderable flow of blood; and thus is the mother delivered from the ſecundines or after-birth. The umbilical cord of the fœtus is next tied, before it is cut off; for it cannot be left open, without danger of a fatal hemorrhagy. Thus the umbilical vein is deprived of all the ſupplies of blood which it uſed to receive, and at the ſame time an inſuperable obſtacle is oppoſed to the blood, conveyed by the arteries of the ſame name.

DCCCCXXXI. The uterus, which hitherto had been diſtended beyond imagination, now contracts itſelf by the elaſtic power of its fibres (DCCCXLIII.), ſo ſuddenly and powerfully, as often to catch and embarraſs the hand of the deliverer, and frequently retain the placenta,

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[190] Twins are conceived in the uterus more frequently than is generally believed, although one is often deſtroyed, and comes away with the ſecundines without any perſon's notice: but the proportion of thoſe which come to the full time is as 1 to 60 or 65.

ta, if it be not ſoon looſened and withdrawn. By this contraction of the womb, the bleeding veſſels are compreſſed, no leſs than by the contraction of their own coats; whence the large quantity of blood that was collected in the uterine ſubſtance abundantly flows out, under the denomination of the *lochia;* at firſt a mere gore, but afterwards, as the openings of the veſſels more contract themſelves, they firſt become yellow, at length become of a whitiſh or wheyiſh complexion; and then the ample wound of the uterus is ſoon healed, and ſhrinks up to a bulk not much exceeding that of the virgin uterus.

DCCCCXLIV. But after two or three days are elapſed from the birth, when the lochial diſcharge has almoſt ſpent itſelf, the *breaſts* begin to ſwell conſiderably; and their ducts, which in the time of geſtation often diſtil a little thin ſerum from the nipple, become now very turgid with a liquor, which is at firſt thin or like whey, but is ſoon after followed by the thicker chyle itſelf. For *milk* very much reſembles chyle, but human milk leſs than that of other animals. It is white, thickiſh, ſweet, and replete with a very ſweet eſſential ſalt, which grows ſour ſpontaneouſly, but is tempered by the oil and lymph added to it. It has alſo a volatile and ſomewhat odorous vapour, a good deal of fat or oily parts, a larger portion of a white craſſamentum or cheeſy curd, and ſtill more of a diluting water; and again, in the craſſamentum, are contained parts of a more earthy, alkaleſcent, or animal nature [191]. But when the chyle is once changed into ſerum, by faſting a conſiderable time, the milk becomes brackiſh, alkaleſcent, and diſpleaſing to the infant. As the chyle, ſo the milk frequently retains the nature of the aliments and medicines taken into the ſtomach. The cauſe of this increaſed ſecretion in the breaſts,

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[191] Milk in its ingredients does not differ much in many animals; but no milk reſiſts acids ſo ſtrongly as the human. It is alſo leſs readily coagulated than aſs or cow milk by alkalis. Alum poured upon woman's milk leaves it untouched; but lime-water coagulates it. The experiments of Hahn and Voltolen, which were made after Spielman's obſervations, are very elegant.

breaſts, ſeems owing to the revulſion, in conſequence of the plentiful uterine ſecretion being ſuppreſſed, by which the fœtus was nouriſhed; in the ſame manner as a diarrhœa is ſuppreſſed by increaſing the perſpiration. For it has been obſerved, that true milk will ſometimes make its way through other parts beſides the breaſts, and even eſcape through wounds. And there is otherwiſe between the uterus and breaſts ſome kind of nervous ſympathy, and a ſimilar fitneſs for generating a white liquor. For the uterus in infancy, and during the time of pregnancy, manifeſtly generates it. But the inoſculations betwixt the mammary and epigaſtric arteries, though true, are ſo ſmall, that they can have but a very little ſhare in this account.

DCCCCXLV. The *breaſts* are made up with a very large quantity of ſoft ſurrounding cellular fat, of a white colour; and conglomerate glandules, of a convex figure, aſſembled into bunches ſomewhat round and hard, of a reddiſh blue colour, outwardly ſurrounded and connected by a firm web of the cellular ſubſtance, ſeparating off into leſſer kernels, which are common both to men and women. To theſe glandules a great number of blood-veſſels are diſtributed from the internal mammaries, from the external veſſels of the thorax, and ſometimes from thoſe of the ſhoulders, all which inoſculate together around the nipple[192]. The trunks of the mammary arteries, but not the *mammales*, inoſculate with the epigaſtric veſſels, but the veins more evidently. The nerves are both large and numerous, like thoſe of the more ſenſible cutaneous parts, being derived from the ſuperior intercoſtals.

DCCCCXLVI. From the middle of this gland of the breaſt, and likewiſe from the ſurrounding fat, an infinite number of ſmall ducts or roots ariſe, very ſlender, ſoft, white, and dilatable, which come from all ſides to the middle of the nipple, and likewiſe into the circle which ſubtends its baſis, and then run together on the area of that circle, and emerge at the root of the nipple, which they perforate round its margin, in a circular figure, after emerging through the root of the ſaid *papilla* or nipple; for by this denomination we call a cavernous or ſpungy cellular body, into which the blood may paſs out from its veſſels, ſo as to cauſe a kind of erection, as in the penis. Through this papilla open about twenty or more of the excretory ducts from the breaſt, called *lactiferous;* none of which inoſculate[193] or join with the others, but are greatly contracted at their opening in the nipple, to what they were in the breaſt: and theſe, in a looſe or flaccid ſtate of the nipple, are compreſſed, wrinkled, and collapſed together; but when the nipple is erected by any kind of titillation, they become ſtraight and open, with patulent mouths, lurking betwixt the cutaneous wrinkles. This papilla or nipple is ſurrounded by a circle, planted with ſebaceous ſmall glandules, which defend the tender ſkin againſt the repeated attrition and perpetual moiſture.

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[192] In order to underſtand the true ſtructure of the female mamma we muſt compare the pretty deſcriptions of Walter and Kolpin with Cubol's obſervations according to Santorinus.

DCCCCXLVII. Thus the infant is naturally provided with its firſt food, which is otherwiſe exceedingly ſalutary to man. This the infant by inſtinct knows how to receive, although it is as yet a ſtranger to all the other offices

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[193] Theſe lactiferous ducts have now been ſo completely and elegantly deſcribed by Meckel and Walter, and likewiſe delineated according to Santorinus, Cubol, and Gerard, that this viſcus, except its lymphatic veſſels, ſeems to be almoſt diſtinctly known. However, theſe famous anatomiſts diſagree; ſome being uncertain whether the lactiferous ducts communicate, which Meckel ſuppoſed, or not, as Cubol, Walter, and Gerard have thought. Whatever experiments I have made with mercury or wax, I was convinced that no ſilver iſſued from the nipple, if I filled one duct; but I muſt not deny, that in a few examples the mercury returned through one or other orifice of the nipple. I have even this winter remarked a double ſet of lymphatic veſſels with which the mammæ abound; moſt of which, gradually collected into a great plexus, go to the axillary glands; but others enter the thorax, through the interſtices of the ribs, in the neighbourhood of the ſternum, and communicate with the conglobate glands of the breaſt, ſituated behind the mammary veſſels.

offices of human life. Taking the nipple in its mouth, it cauſes it to ſwell by gentle vellications; the lips are preſſed cloſe to the breaſt, that no air may enter betwixt; at the ſame time the inſpiration is deep, and a ſpace formed in the back part of the mouth, in which the air is more dilated or rarefied; and thus, by the preſſure of the external air, joined with that from the lips of the infant, the milk is urged from the breaſt thro' the nipple, in which it would otherwiſe be collected in ſo great a quantity, as ſometimes to diſtil ſpontaneouſly and be very ready to flow out; and thus the infant ſucks, and is nouriſhed. The firſt milk, which is like whey, termed *coloſtra*, looſens the tenders bowels of the infant, and purges out the meconium (DCCCXCVIII.), to the great advantage of the infant. Yet it is alſo obſervable, the lactiferous ducts are ſo open, that when the nipples of the breaſt are diſtended by titillation, and a greater quantity of blood ſent into the breaſts, they have yielded milk, even from virgins, ſometimes from old women, or even from men. Milk is only generated after puberty; before that a time a ſerous humour flows from the breaſt; and for the moſt part it is generated only about the middle of pregnancy. After the menſes have ceaſed, the breaſts, as well as the uterus, become decayed, and ceaſe to perform their office.

DCCCCXLVIII. But great changes now happen to the little new-born infant; and the firſt is *reſpiration*, which it endeavours to exert, even before it is well ſet at liberty from the vagina of the mother, being probably excited, from the pain or anguiſh it feels, to thoſe cries with which it ſalutes the light, and perhaps from the deſire of food which it had hitherto taken in from the liquor of the amnios. At firſt, therefore, a portion of the air is admitted into the lungs, which are as yet ſmall and full of moiſt vapours; but being dilated from the air, change from a ſmall denſe body, ſinking even in ſalt water, into a light ſpungy floating fabric, extended to a conſiderable bulk with air, and of a white colour. Now, therefore, the blood paſſes more eaſily into the enlarged and looſe fabric of the lungs (CCLXV.); in conſequence of which, a large portion of the blood that went before from the pulmonary artery, through the canalis arterioſus, into the aorta, goes now into and through the lungs themſelves, by the other branches of the ſaid pulmonary artery. And ſo much the more is the arterial duct or canal deſerted, inaſmuch as there is made a new obſtacle to the deſcent of the blood into the abdomen; for the umbilical arteries being now very ſtraitly tied, the blood of the deſcending aorta cannot now find its way but by the ſame force with which it dilates all the arteries of the pelvis and lower extremities. Finally, as the lungs now receive more blood, ſo the aorta itſelf receives a greater quantity, and with greater force likewiſe from the heart; whereupon the intermediate canal, betwixt the protuberant part of the aorta and pulmonary artery, cloſes up or ſhrinks to ſuch a degree, that, in adults, it is not only an empty ligament, but likewiſe of very little length; and otherwiſe it is ſingularly red in the inner part, ſoft, and very fit for concreting with the ſtagnating blood. This courſe of the blood, therefore, is ſoon aboliſhed, commonly in about the compaſs of a year.

DCCCCXLIX. In the like manner alſo, the foramen ovale is, from the ſame cauſes, gradually cloſed up. For when the way is rendered more free and pervious into the lungs, it will likewiſe be more free into the right ſide of the heart; whence the blood, both of the aſcending and deſcending cava, will flow thither more plentifully, as it is invited by the more lax pulmonary artery, into which it will rather move, than through the paſſage through the ſeptum of the ſinuſes. Again, the umbilical vein, being now almoſt deſtitute of any ſupply with blood from the ligature of the navel (DCCCCXXX.), leſs blood will from thence flow into the lower cava, and conſequently the preſſure againſt the oval mouth will be diminiſhed; by which means the blood of the upper cava, being turned off by the iſthmus, will be ſcarce able to penetrate the obliquity of the foramen ovale. Thence again, as more blood is derived through the lungs into the left ſinus and auricle, its greater dilatation and extenſion will ſtrain the little horns of the oval valve, ſo as to draw up and preſs the valve, together with the iſthmus, whereby it is extended ſo far, as wholly to ſhut up the opening in the mature infant, while, at the ſame time, the blood, within the left ſinus, props up the ſaid valve, ſo as to ſuſtain the impulſe of the blood on the other ſide within the right ſinus. Thus, by the acceſſion of a little friction of the uppermoſt margin of the valve againſt the upper part of the iſthmus, the foramen ovale cloſes up by degrees, and the upper margin of the valve forms a concretion to the poſterior face of the iſthmus. But this is performed very ſlowly; inſomuch that frequently, in an advanced age, there will be ſome ſmall aperture or tube ſtill remaining; and where there is none of this tube, yet there are the remains of one, as a kind of ſinus, hollow to the left ſide, that makes a tube opening upward to the right ſide, and blind or cloſed to the left, becauſe the power of the blood in the right ſide is always greater than its reſiſtance on the left, or certainly not leſs, even in the advance of life.

DCCCCL. The *umbilical vein*, being deprived of blood, ſoon cloſes up. The blood of the vena portarum, having no oppoſition from that which formerly flowed through the umbilical vein, occupies the left ſinus and curve of the umbilical foſſa (DCXCV.), and ſends its blood through thoſe branches by which that of the umbilical vein before paſſed. Thence the *ductus venoſus* being neglected, ſhrinks up and cloſes, by the new compreſſure which the deſcending diaphragm makes upon the liver by inſpiration; and by which the left lobe of the liver is preſſed towards the lobule, and perhaps too from the obtuſe angle which it makes with the left ſinus of the vena portarum; for it is certainly firſt cloſed in that part which lies next the vena portarum.

DCCCCLI. The *umbilical arteries* are alſo cloſed up from the ſame cauſes, as other arteries uſually are after

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a ligature, when ſome of the blood being at the ſame time compacted into a polypus, fills up the blind void part, while the other blood, flowing above, whoſe impulſe was ſuſtained by the reſiſting membranes, ſpreads itſelf through the adjacent leſs reſiſting branches, which are thereby rendered more open or diverging. Nor do I overlook the force of the abdominal muſcles towards this effect, by which thoſe arteries are compreſſed againſt the full abdomen in each reſpiration; and, again, the very acute angle in which the umbilicalis goes off from the iliac artery, now becomes a curve, by deſcending with the ſides of the bladder, and is then directly extended into an acute fold, which the thighs make with the body of the fœtus. Thus the capacity of theſe arteries is ſoon ſhut up, leaving only a ſmall tube, that gives paſſage into two or three arteries of the bladder. The *urachus* being likewiſe a very thin tube, extended perpendicularly upward from the bladder, is therefore eaſily cloſed up; ſo that the contents of the bladder make no endeavours to paſs that way, finding a ready outlet by the deſcending urethra.

DCCCCLII. From the like cauſes the bulk of the liver itſelf is leſſened, and by degrees contracts itſelf within the capacity of the ribs; in the mean time the inteſtina craſſa, from the ſlender condition in which they are obſerved in the fœtus, dilate to a conſiderable diameter, and the ſtomach itſelf is gradually elongated; the large convexity of the cæcum forms itſelf by the force of the feces preſſing perpendicularly downward to the right ſide of the vermicular appendix; and the lower limbs are likewiſe conſiderably enlarged by the return of the blood, ſent back from the umbilical arteries now tied; and by degrees all the other changes are made, by which a fœtus inſenſibly advances to the nature and perfection of an adult perſon.

CHAP. XXXII.

Nutrition, Growth, Life, *and* Death.

DCCCCLIII. After birth the child continues to grow, but always more ſlowly the older it is. There are many concurring cauſes, why the growth is continually rendered leſs and leſs. Many veſſels ſeem to be ſtopped up, both becauſe they are compreſſed by the neighbouring torrent of blood flowing through the great arterious tube, and becauſe the blood being now become more viſcid runs into clots. But the harder kind of food that is now made uſe of, throws into the blood more terreſtrial parts, which being carried through the whole body along with the nutritious parts, renders them all harder, as the bones, teeth, cartilages, tendons, ligaments, veſſels, muſcles, membranes, and cellular texture; ſo that an increaſe of hardneſs may be perceived in them, even by touching them with the finger. Wherefore, ſeeing the blood flows from the heart through fewer canals, and ſeeing all parts are grown harder, which ſhould be lengthened or diſtended, it neceſſarily follows, that thoſe which ought to increaſe in bulk, will yield leſs and leſs to the impulſe of the heart.

DCCCCLIV. But the heart likewiſe, which is the part that is firſt conſolidated among all the ſoft ones, increaſes leſs than any other part of the whole body; and while the much more tender limbs and ſofter viſcera are diſtended, the proportional bulk of the heart to the reſt of the body grows continually leſs and leſs, till at laſt its proportion to the body of the adult becomes eight times leſs than what it was in the new-born infant. At the ſame time, from that very denſity which it has ſo quickly acquired, it becomes leſs irritable, and is contracted leſs frequently within a given time. Thus, while the reſiſting forces are augmented, the diſtending ones are at the ſame time diminiſhed.

DCCCCLV. There will therefore, ſooner or later, be an end of the increaſe of bulk; and that will happen ſo much the ſooner as the heart has had the more frequent and vivid contractions: but this ceſſation of growth will take place when the cartilaginous cruſts of all the bones are now become ſo thin that they cannot yield to the increaſe of the bony part. In women the menſes ſeem to put a ſtop to the growth ſooner than in men. In cartilaginous fiſhes, there is perpetual growth.

DCCCCLVI. There is no ſtate in which nature by a perennial progreſs induces a continual decreaſe from the firſt conception. It is ſaid however to take place, when there is neither any increaſe of bulk, nor yet does any viſible decreaſe take place.

DCCCCLVII. For we are all perpetually conſuming (CCCCXXXIV). Nor do we only loſe the fluid parts of our bodies, but in ſhort even thoſe which are reckoned to be the moſt ſolid. For even the bones are changed; and the teeth, which are harder than the bones, increaſe in bulk when the attrition of the oppoſite teeth has ceaſed to wear them away, and therefore their elements are changed: even the fibres of ivory in the elephant's teeth have quitted their places, and ſurrounded on each ſide in curve lines a leaden ſhot: the bony juice likewiſe is changed; ſeeing in ſome caſes the bones grow ſoft, in others they ſwell out in bony tumours: even cicatrices themſelves have a manifeſt growth, otherwiſe they would not be ſufficient in an adult perſon to cloſe up a wound which he had received, when a boy; and a great quantity of the earthy part of our bodies goes off by urine, as is proved by ſome diſeaſes.

DCCCCLVIII. The cauſe of the deſtruction of the ſolid parts lies in their perpetual extenſion and retraction, which happens at every pulſe of the heart: this occurs an hundred thouſand times every day, and by this motion even metals themſelves are worn. Other cauſes are from the friction of the fluid againſt the ſolid parts; from the wearing away of all the membranes, which terminate with a moveable extremity, either on the ſurface or in the internal cavities of the body, the firmneſs of which only belongs to the reſt of the canal; in the alternate ſwelling and decreaſe of the muſcles; and in the attraction and preſſure which at firſt form our fleſhy parts. But all parts of our body are the ſooner worn away, that they conſiſt of a great deal of gluten combined with a ſmall quantity of earth; and that gluten when it is extended, if the extenſion has been a little ſuperior to the force of its coheſion, muſt of neceſſity fall away and be carried off from the earthy parts. Thus wrinkles or furrows are generated; ſuch as are viſible in the arteries of old men. The cellular texture, which otherwiſe would be diſſolved into water or gelly, is worn away by the impetus of the blood preſſing againſt the neighbouring blood-veſſels and muſcles, by friction, and by perpetual flexion and extenſion.

DCCCCLIX. The decreaſe would be very quick, and indeed there would be no great diſtance between the end of our life and its beginning, unleſs theſe loſſes were repaired. The fluid parts are reſtored by the aliments, and that pretty quickly; as appears from the example of a chicken, in which blood is generated out of its aliment within two days. The fat, however, and red globules of blood, are formed out of the fat, as is ſhown elſewhere; the lymphatic juice from jelly; the mucus from mucus; and the reſt of the humours from theſe and water. The ſolid parts are repaired almoſt by the ſame methods which we have deſcribed in the hiſtory of the fœtus. A gelatinous juice is brought from the aliments, through the arteries, to all parts of the body, and exſudes into all parts of the cellular texture. The furrows, which we might imagine to be made in the inmoſt arterial membrane by the impetus of the blood, are filled up by a viſcid matter brought into them by the lateral preſſure; nor is it poſſible that theſe furrows can be overfilled, becauſe every exuberant particle of nutritious juice muſt neceſſarily be carried off by the current of the blood. This will not be wanting while there is a ſufficient quantity of aliment;

while there is more reſt, and leſs reſiſtance, in the bottom of the furrow than elſewhere, which always muſt be the caſe, becauſe the bottom is farther removed from the motion of the blood by the depth of its cavity. There ſeem to be certain powers in the air[194], by which the aliment is attached to the ſolid parts, although we are ignorant of the manner in which they act.

DCCCCLX. The decreaſe of the cellular texture ariſing from attraction or preſſure, will be repaired by the viſcid vapour exhaling from the artery, and preſſed towards thoſe places which ſtand in need of reparation by the force of the neighbouring arteries and compreſſing muſcles, its aqueous part being preſſed out and reſorbed. The gluten repairs moſt of the organic parts, tendons, and membranes; being formed into a new cellular texture, as in the fœtus.

DCCCCLXI. The waſte which takes place in moveable parts adhering by their other extremity to the reſt of the body, can be repaired by protruſion alone, while the lymph fills up the intervals or hollows that are thus produced.

DCCCCLXII. At that time when the growth of the body can proceed no farther, fatneſs is produced, which is a kind of imitation of real growth. This proceeds from the fat generated by the aliment; which by reaſon of the impetus of the blood being leſſened, and its entering the ſmalleſt veſſels with more difficulty, is carried to the ſides of the veſſels; enters the lateral ones and the inorganic pores of the arteries; exſudes into the cellular texture; and there, the power of conquaſſation of the blood being now diminiſhed, and likewiſe the abſorption by the veins, the fat is conſequently collected.

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[194] It was formely rendered probable by Hales, that air contributed greatly to the coheſion of bodies: and this doctrine has been lately confirmed by Achard's experiments, by the application of fixed air to form cryſtals: Prieſtley and Ingenhouz have proved unqueſtionably, what ſervice, in general, the air and its different particles do in the buſineſs of nutrition.

DCCCCLXIII. We feel the beginnings of decay even in youth itſelf. Even in that blooming ſeaſon the ſolid elements of the body are augmented, the chinks through which the humours flow are leſſened, ſmall veſſels filled up, and the greater attraction of the cellular texture has added a denſity to the whole body. Throughout the whole body that hardneſs occaſioned by age is very conſpicuous, in the bones now wholly brittle, in the ſkin, in the tendons, in the conglobate glands, in the arteries, and likewiſe in the weight of all the parts, and of the brain itſelf. But thoſe parts grow ſtiff ſooneſt which are moſt exerciſed by motion; as thoſe in every mechanic, which he chiefly makes uſe of in his buſineſs.

DCCCCLXIV. Moreover, the arteries alſo continue to become more denſe, more narrow, and even to be quite filled up, as well by the internal preſſure of the blood flowing through the large arterial tube, as from the attraction of the cellular texture of which the greateſt part of the artery is made up. An infinite number of parts of the cellular texture thereof ceaſe to be nouriſhed; to which the ſmalleſt arteries hitherto brought their nouriſhment, but now when ſtopped up can bring none. The extending force being removed, the cellular fleeces draw themſelves together, contract the little ſpaces intercepted between them, degenerate into membranes, or ſubſtances of a hard texture, which intercept and as it were choak up other veſſels. But the gelatinous vapour likewiſe concretes in the ſmall hollows of the cellular texture, and unites into a hard ſolid with its ſides. The muſcles, having expelled the blood they contained, and condenſed their fibres, degenerate into hard denſe tendons deſtitute of all irritable power.

DCCCCLXV. At the ſame time the nerves become more and more callous to the impreſſions of the ſenſes, and the muſcules grow leſs ſenſible to the ſolicitations of the animal powers; thus the contractile force of the heart, and the frequency of its pulſations, is diminiſhed, ed, and therefore the whole force which drives the blood into the ſmalleſt veſſels.

DCCCCLXVI. The quantity of humours is diminiſhed in a denſe body, as is evident in the perſpiration, ſemen, humours of the eye, and of the conglobate glands; the vapour alſo which bedews the ſolid parts of the body, every where decreaſes. For this reaſon nutrition now languiſhes, becauſe there are more parts of the body which require nouriſhment, and leſs nutritious juice.

DCCCCLXVII. Nor is the quantity of humours only diminiſhed: they themſelves are likewiſe corrupted. They were mild and viſcid in children: but theſe ſame humours are now acrid, ſalt, fetid, with a great quantity of earth, in old men. This happens through the uſe of ſalt or putrid aliments, the fault of which grows ſtronger by being collected through a great length of time; alſo through the fault of a leſs perſpirable ſkin, a coſtive belly on account of the diminiſhed irritability, and thus the increaſed reſorption of the putrid liquamen. Hence the fetor of the urine, of the breath, and the difficult healing of wounds.

DCCCCLXVIII. But the greateſt fault of the humours is, that they abound with earthy particles, as well thoſe collected inſenſibly from the aliments after the ſecretions have become leſs free, as from thoſe which are carried off from the ſolid parts and returned into the blood: of this conſiſts the earth collected in ſome diſeaſes, and which is of the nature of the gouty earth. By this quantity of earth, the portion of that element through the whole body is augmented, becauſe the nutritious liquor brings too much of that along with it; whence the brittleneſs of the bones, and the hardneſs of all the other parts, increaſes: the ſame is likewiſe every where depoſited in the cellular texture, and produces cruſts, which are firſt callous, then of a bony or ſtony nature, and that chiefly in the coats of the arteries.

DCCCCLXIX. The hardneſs or rigidity of the whole body, the decreaſe of the muſcular powers, and the weakening of the ſenſes, conſtitute *old age;* which happens to mankind ſometimes ſooner, and ſometimes later: ſooner if they have been ſubjected to violent labour, or given themſelves up to pleaſure, or lived upon unwholeſome diet; but more ſlowly if they have followed a moderate way of life, and uſed temperance in their diet, or if they have removed from a cold to a warm country[195].

DCCCCLXX. But when thoſe cauſes continue to operate by rendering the matter of the body more denſe, by diminiſhing its irritability, and augmenting the quantity of earth, it is not poſſible but decrepid old age muſt ſucceed. In it the ſenſes are almoſt deſtroyed, the natural power of the muſcles is exceedingly weak, the limbs loſe their ſtrength, the feet eſpecially are not ſufficient for ſupporting and directing the body. Thus the callous inſenſibility of the nerves cannot be incited to perform the office of generation: thus the very inteſtines becoming inactive, refuſe to anſwer to the accuſtomed ſolicitations: thus alſo, by the induration of the cartilages interpoſed betwixt the vertebræ, the body bends forward; by the falling out of the teeth, the jaws now rendered ſhorter cannot ſupport the lips as uſual; and laſtly, the heart loſes one half of the frequency of its pulſation which it had in the infant ſtate.

DCCCCLXXI. Thus at laſt natural death neceſſarily follows; but very many people are carried off before this time by diſeaſes. Scarce one in a thouſand exceeds the age of 90; but one or two perhaps may be found in a century that live to the age of 150. Man is long lived when compared with other animals; he is alſo more tender than any of them, has looſer fleſh, and leſs hard bones. Among the long-lived people, it is not eaſy to ſay what was the cauſe of that privilege. England ſeems to excel all other nations in the long-lived people; and generally the temperate countries are remarkable in this reſpect. Among all the different profeſſions, the commonalty has almoſt ſolely afforded theſe rare examples of longevity already mentioned; although from the more numerous claſs, we might expect a greater number of examples. Some prerogatives of long life ſeem to be ſobriety, at leaſt a moderate and not very rich diet; a mild behaviour; a mind not endowed with very great vivacity, but cheerful, and little ſubject to care. Among animals, fowls are longer lived than many others, but fiſhes the moſt of all; the latter have the ſmalleſt heart, and the ſloweſt growth, and their bones are never hardened.

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[195] That the change of climate is not always ſufficient to ward off old age, and to prolong life, we find by daily experience; ſeeing ſo many phthiſical and hypochondriac perſons, from every part of the north of Europe, from Britain in particular, betake themſelves to Italy or the ſouth of France, without the hoped for relief. Sulzer is ſtill recent in our memory.

DCCCCLXXII. Death happens ſometimes, but rarely, from mere old age. This we ſay happens when the powers are gradually loſt, firſt of the muſcles ſubject to the will, then of thoſe that are ſubſervient to the vital functions, and laſtly of the heart itſelf; ſo that old men ceaſe to live through mere weakneſs, rather than thro' the oppreſſion of any diſeaſe. I have often obſerved the ſame kind of death in brutes. The heart becomes unable to propel the blood to the extremities, the pulſe and heat deſert the feet and hands; yet the blood continues to be ſent forth from the heart into thoſe arteries that are next to it, and to be carried back from thence: thus the flame of life is ſupported for a little while; which we ſoon perceive to be extinguiſhed, when now the heart itſelf being totally deprived of its powers, and not irritable by the blood to any effectual motion, cannot drive the blood through the lungs, that the aorta may receive its due quantity. Thus the utmoſt force of reſpiration is exerted in order to open a paſſage to the blood through the lungs, until even the powers given by nature for performing the action of inſpiration, become unequal to their taſk, and ceaſe altogether. Thus the left ſide of the heart neither receives blood nor is irritated, and therefore remains at reſt; while yet for a little time the right ventricle, and laſtly the auricle of the ſame ſide, receive the blood brought by the veins from the cold and contracted limbs, and by this means being irritated they continue to beat weakly. But laſtly, when the reſt of the body has become perfectly cold, and the fat itſelf congealed, even this motion ceaſes, and death becomes complete.

DCCCCLXXIII. I would call that death, when the whole irritable nature has left the heart. For the mere reſting of the heart is not without hope of a revival of motion: neither does the putrefaction of any part of the animal body demonſtrate the death of the whole animal; nor does its inſenſibility or coldneſs do ſo: but all theſe things when joined together, and perpetually increaſing, with the ſtiffneſs which follows the coagulation of the fat by reſt and cold, preſent the ſigns of death in any doubtful caſe.

DCCCCLXXIV. The dead body now haſtens to putrefaction. The fat, water, and gluten, in conſequence of ſeparation and diſſolution, conſume: the earth, deprived of its bonds of union, inſenſibly moulders away, and mixes itſelf with the duſt: The ſpirit departs whither God hath deſtined it. By death it is indeſtructible; which is manifeſt from the common and frequent obſervation of phthiſical people, who, while their bodily powers are waſting by diſeaſe, evidently poſſeſs a moſt ſerene, lively, and joyful mind.

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That this is performed by the external intercoſtal muſcles.
358. The internal intercoſtals.
There are doubts concerning the action of theſe, but it is certain that they are elevated
259. By what means theſe enlarge the thorax. They are not, however, ſufficient to perform this dilatation
260, 261. The diaphragm
262. The two holes of the ſeptum
263. That the contraction of the ſeptum augments the capacity of the thorax
But that this is performed only by means of reſpiration
264. What powers conſpire to produce the more deep inſpirations
265. Inſpiration how performed
Its effects on the air and blood-veſſels
266. Whether there is air between the lungs and thorax
267. That the air is vitiated by reſpiration
268. The inconveniences of too long an inſpiration
269. The powers of exſpiration
270. That the abdominal muſcles conſpire to produce this effect
That the ſternocoſtals and others alſo aſſiſt
271. What powers aſſiſt the muſcles in the ſtronger reſpirations
272. The effects of exſpiration
273. That from thence there ariſes a new neceſſity for reſpiration
274. That we can ſcarce aſſign any other cauſes for alternate reſpiration
275. That reſpiration is neceſſary for an adult
276. That the uſefulneſs of reſpiration is different from that neceſſity
277. From whence theſe things are diſcovered
278. Whether animal-heat is generated in the lungs
279. Whether the blood is condenſed in the lungs
280. Whether air itſelf is received into the blood in the lungs
What things render this probable
281. What things ſeem to prove the contrary
282. Whether the blood is cooled in the lungs
283. Whether the red colour of the blood proceeds from the air
285. Whether the uſe of the blood is to abſorb nitre from the air
286. What animals live long without air
Why every animal dies in air that is not often changed
287. What is the agreement between the pulſe and reſpiration
288. Cough
289. Laughter
Weeping
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Sneezing
290. The acceſſory uſes of reſpiration.

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291. That the larynx is made of cartilages
Its veſſels and nerves
292. The ſcutiform cartilage
293. The annular cartilage
294. The arytenoide cartilages
295. The glottis
296. The epiglottis
297. The ventricles of the larynx
298. The mucous glandules of the larynx
299. The thyreoide glandule
300. The connexion of the larynx with the os hyoides
The elevation and narrowing of the larynx and glottis
301. The depreſſion and dilatation of the larynx and glottis
302. The cavity of the mouth
The noſtrils
303. The tongue
304. The voice
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305. The ſtrength of the voice
How an acute tone is made
306. That a grave tone is produced by oppoſite cauſes
307. The cauſes of a diverſity of tones
308. Singing
309. Speech
310. The pronunciation of letters.

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311. A conſideration of the order
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312. The arch of the aorta, and the branches produced from it
313. The diviſion of the carotid
The external carotid. From it proceeds
The ſuperior thyreoide artery
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The labial one
The aſcending pharyngea
314. The occipital artery
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315. The temporal artery
The internal maxillary one
316. The principal branch to the dura mater
Other branches of the internal maxillary
316. *The internal carotid
Its angles
Its paſſage through the foramen of the os petroſum
The branches produced from it in the receptacle
317. The branches of the internal carotid on the bridge and crura of the brain
The branch accompanying the plexus choroides and optic nerve
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318. What may be collected from the hiſtory of the arteries of the brain
320. 324. The coverings of the brain
320. The bony covering of the encephalon
The hard membranes in general
321. The external and internal lamina of the hard membrane
The falx and tentoria proceed from theſe, and what is their uſe
322. The glands
323. The arachnoid membrane
324. The pia mater
325. 339. The veins of the encephalon
325. The fourth ſinus

326. The ſuperior ſinus of the falx
The tranſverſe ſinuſes
327. The inferior ſinus of the falx
328. The inferior, anterior, and poſterior veins of the brain
329. The veins of the cerebellum
That the ſuperior ones terminate in the fourth ſinus; the inferior ones in the ſuperior and tranſverſe ſinus of the os petroſum
330. A ſinus like a circle
The tranſverſe ſinuſes joining the cavernous ones
331. The ſuperior ſinus petroſus
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The poſterior occipital ſinus
332. The anterior occipital ſinus
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The conjunction of the ſinuſes and external veins of the cranium with one another, and what happens from thence
333. The uſe of the ſinuſes
334. What happens to the arteries with the ſinuſes
335. That the blood chiefly flows into the jugular veins
Their cerebral and facial branches
336. The external jugular vein
The internal vertebral vein
337. The ſinus of the medulla ſpinalis
338. The uſes of the venal anaſtomoſes
339. The lymphatic veſſels of the brain
The reſorption of that which exhales in the brain
340. That a great number of parts are comprehended under the name of *encephalon*
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341. The figure of the brain
Its *gyri* or circumvolutions
Its cortex
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342. The more ſubtile ſtructure of the brain
343. 53. The interior anatomy of the brain
343. The oval ſection of the brain
The corpus calloſum
344. The anterior or three-horned ventricle
345. The corpora ſtriata
The thalami of the optic nerves
The double ſemicircular centre
The anterior commiſſure
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346. The pellucid ſeptum
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347. The choroid plexus
348. The third ventricle
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350. The poſterior double commiſſure
351. The ſeparation of the third ventricle from the calamus ſcriptorius
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352. The nates
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353. The crura of the brain
354. The cerebellum
355. The bridge
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356. The common origins of the nerves of the brain
357. The origins of each of the ſingle nerves of the brain
358. The medulla ſpinalis
The pia mater, arteries, and veins of the ſame
359. The arachnoid membrane of the medulla ſpinalis

360. The

360. The hard membrane of the medulla ſpinalis
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361. The common properties of the ſpinal nerves
362. The anterior and poſterior trunks of the ſpinal nerves
The intercoſtal nerve
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The phrenic nerve
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364. The extremity of the nerves
The ſtraightneſs of the fibres of the nerves
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The number of nerves in proportion to the parts to which they are ſent
The anaſtomoſes of the nerves
Ganglions
365. How it is proved that ſenſation is owing to the nerves
That it is the medullary part of the nerve which feels
366. That the ſoul perceives in the brain, not immediately by the ſenſoria and branches of the nerves
367. How the muſcles are affected by compreſſing or irritating the nerves
368. What impediments of the animal motions happen on hurting the brain or ſpinal marrow
369. From what is laid down in 367 and 368, the nerves are proved likewiſe to be the organs of motion
370. Whether there is in the brain any principal ſeat in which is the origin of all motions, and the end of all ſenſation, where the ſoul reſides
That that ſeat is not in the corpus calloſum
371. Nor is it the proper province of the cerebellum to carry on the vital motions
Nor are we to derive the motions called *animal* and *vital* from different ſources
372. That the ſeat of the ſoul is where the nerves firſt begin
373. That the nerves are the organs of ſenſation and motion, not by their membranes, but their medullary part
374. What the medulla is
375. Whether a medullary fibre is ſolid
376. That the nerves are entirely devoid of elaſticity
377. That motion can only be propagated downwards
That from what is already ſaid, it follows, that the medullary fibre ſeems to be hollow
378. A diſproof of the objections uſually brought againſt this
379. The nature of the nervous fluid
How proved not to be electrical
380. That the nature of that fluid is neither aqueous nor albuminous
381. Of what kind the nervous fluid ought to be
382. How it is rendered more probable that the nervous fluid paſſes through a hollow tube than through a ſpongy ſolid
383. A double motion of the nervous juice
384. That the ſame nerves moſt evidently ſerve both for ſenſe and motion
385. What becomes of the nervous fluid
Whether it nouriſhes the body
386. Queſtions concerning the uſes of the different parts of the brain
387. The offices of the ventricles
388. What is known concerning the uſe of the tubercles
389. The offices of the ſtriæ and the internal ducts
390. The order of thoſe things which follow conſidered.

Chap. XII. MUSCULAR MOTION.

391. What is called the dead power of the fibre
392. The reaſon why it is called *dead*
Its effects
393. The power of the dead fibre commonly known.
The properties of the common red muſcular fibre
394. What the fibres of a muſcle, and the muſcle itſelf, are
395. The fibres treated more fully
396. The belly, tendon, aponeuroſis, and capſule of a muſcle, what
Whether the fibres of the tendons are of a different genus from the muſcular ones
The parts in which the muſcles go off in long tendons, and thoſe to which they affix themſelves
397. The reaſons of the tendons uniting themſelves with the fleſh
A pennated muſcle, what
398. The arteries, veins, lymphatics, and nerves, of the muſcles
399. The ſtructure of the leaſt fibre which ſerves as an element to the muſcle
400. That there is a threefold force in the muſcle
The *vis inſita* of the muſcle
401. The meaſure of the muſcles ſhortening when they contract
402. Other things which relate to the *vis inſita*
403. The nervous power of the muſcle
404. In what the nervous power and *vis inſita* differ
405. The phenomena in the motion of the muſcles ariſing from the nervous power and *vis inſita*
406. What the arteries contribute to the motion of the muſcles
407. A refutation of the cauſes by which the nerves are ſaid to move the muſcles
408. That the nervous fluid ſeems to ſerve in the place of a ſtimulus; and that its moving cauſe is not the ſoul, but a law derived from God
409. What things ſhow that in the motion ariſing from the *vis inſita*, the ſoul does not interfere
410. What things happen to the muſcles obeying the will, and to thoſe which are governed by a *vis inſita*
411. The magnitude and loſs of the powers which the muſcles exert in their contractions
412. The proportion of theſe loſſes
313. What thoſe that are called antagoniſts contribute to the motion of the muſcles
414. Other helps to this motion
416. The co-operation of the muſcles
417. What effects are produced by the action of the muſcles
418. The relaxation of a ſtretched muſcle
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419. What feeling is
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420. Touch in general
421. Touch in another and more proper ſenſe
422. The true ſkin
423. The granules and papillæ of the ſkin
424. The epidermis
425. The rete Malpighianum
426. Of what the net-work and epidermis are made
427. The glands of the ſkin
That there is another ſpring of oily liquor, and what it is
428. The hairs
429. The nails
430. That the ſubcutaneous cellular texture in very few places is free of fat
What purpoſe it ſerves after it has received the fat
That the ſkin and Malpighian mucus, where they ſeem perforated, are drawn inward and degenerate
431. The reaſon of feeling, and the qualities which are known from thence
432. The Malpighian mucus, hairs and nails, what purpoſe they ſerve
433. A vapour perſpires through an infinite number of little arteries of the ſkin
434. The ways of demonſtrating this exhalation
435. Sweat
436. The elements of perſpiration
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The odours of aliments
The electric matter
437. Another volatile element of perſpiration, ſomething of an alkaline nature
438. The quantity of perſpiring liquid
439. Of what uſe the quantity of perſpiring liquid is
What things augment or diminiſh it, and what follows from thence
440. How ſweat benefits or hurts the body
441. The uſe of perſpiration
442. Inhalation, by what arguments it is proved
443. How it is proved that both the exhaling and inhaling veſſels may be contracted and relaxed by the power of the nerves.

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444. That taſte is chiefly exerciſed by the tongue
445. The tongue in general
Firſt kind of its papillæ
446. The fungiform papillæ
The conical ones
Others which intervene
447. The nerves of the tongue
448. The arterious and nervous villi which run between them
449. The covering of the tongue
450. The muſcles of the tongue
451. The veſſels of the tongue
452. The manner of exerciſing the taſte
Flavours, and their cauſe
453. What things contribute to the perception of taſtes
454. That the ſpirits are reſumed either into the papillæ or the abſorbing villi of the tongue
455. The uſe of the ſenſe of taſte.

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456. The uſe of ſmell
457. That ſmell is exerciſed by the help of the membrane of the noſtrils
The nerves of that membrane
458. The arteries, membranes, and veins of the noſtrils
459. What the noſtrils are
The ſeptum of the noſtrils
560. The uppermoſt, middle, and loweſt oſſa ſpongioſa
461. The ſinuſes in general, what they are
The frontal ſinuſes
462. The ethmoidal ſinuſes
The ſinus of the multiform bone
463. The ſinus of the maxillary bone
464. The mucus of the noſtrils
The ſinuſes abounding in mucus can evacuate it in any ſituation of the body
465. The noſe and its muſcles
466. The manner of exerciſing the ſenſe of ſmell
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467. The ſtrength of odours
The parts of the noſtrils which primarily belong to the ſenſe of ſmelling.

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468. The reaſon of the difference between the organ of hearing and that of the other ſenſes
469. The lap of the ear and its parts
470. The glandules and muſcles of the lap of the ear
471. The meatus auditorius
472. The ſkin and cuticle of the meatus
The glandules for ſeparating its wax, and the wax itſelf
473. 477. Air, according to the natural philoſophers
474. Tones
475. The velocity of ſounds
476. Sympathetic tremors
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477. How ſound rebounds from hard bodies
The reaſons of the increaſe and weakneſs of ſounds
478. The collection of ſounds in the meatus auditorius
479. The membrane of the tympanum
That the ſounds ſtrike upon it after their ultimate reflexion in the meatus auditorius
480. The tympanum
481. That the four little bones which perform the office of hearing are placed in the tympanum
The malleus
482. The muſcles of the malleus
The effects of a ruptured membrane of the tympanum
483. The incus
484. The ſtapes and its muſcle
485. The little round bone
486. The various canals go out of the cavity of the tympanum
A certain appendix to the tympanum, of the figure of a gnomon
Small cells above the mamillary proceſs, and in the proceſs itſelf
487. The tube
488. That two other paſſages lead from the tympanum into the labyrinth
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489. The

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490. The round feneſtra
The cochlea
491. The veſſels of the organ of hearing
492. The nerves belonging to this organ remain to be deſcribed
The ſeventh pair of nerves, and its hard portion
The nerves of the lap of the ear
493. The ſoft branch of the ſeventh pair of nerves
494, 5. Various things concerning the ſeat of hearing
496. What things are more certainly underſtood concerning this matter
497. The diſtinction and gratefulneſs of ſound.

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498. The difference between ſight and hearing
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499. The eye-brow
500. The palpebræ
The conjunctiva
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501. The tarſus
The levator muſcle of the ſuperior palpebra
The orbicularis palpebrarum
502. The cilia
503. The Meibomian ſebaceous glands
504. The tears and their fountains
505. The duct of the lacrymal glands
The effects of the contraction of the orbicular muſcle
506. What becomes of the tears
The caruncula lacrymalis
The third palpebra
The punctum lacrymale
507. The ductus lacrymalis
The lacrymal ſac
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508. The figure of the eye
The orbit
The fat poured out around it
509. The optic nerve
Its progreſs
510. What afterwards becomes of that which touches the eye
511. The ſclerotica
The cornea
512. The choroides
The Ruyſchian lamina
The ciliary circle
The pupil
The iris
The uvea
The membrane covering the pupil in the fœtus
513. The motion of the iris
514. The ciliary ligaments
515. The retina
516. The humours of the eye
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517. The cryſtalline lens
518. The aqueous humour
The arches of the eye
519. The ſtraight muſcles of the eye
520. The oblique muſcles of the eye
521, 522. The nerves of the eye
521. The ophthalmic branch of the fifth pair
522. The branches of the third pair
523. The motion of the ciliary proceſſes
524, 527. The arteries of the eye
528. The veins of the eye
529. Light in general
530. That light conſiſts of rays ſhowing different colours
531. The colours proper to every body, whence they come
Opake bodies what

532. How refraction happens, and what it is
533. When rays fall on a convex ſpheric body, which of them are refracted, and which reflected
The focus of the refracted ones
534. What rays falling upon the cornea are reflected, or being refracted are ſuffocated or come to the lens
535. How the rays are refracted in their paſſage through the cornea and aqueous humour
536. How they are refracted by the cryſtalline humour
538. How they are refracted by the vitreous humour, and are at laſt collected upon the retina
539. Whether objects are rather painted on the choroides
540, 541. How the eye is thought to accommodate itſelf to the various diſtances of objects
542. But that nothing of this kind happens
543. Myopia
544. The cure of this diſorder
545. Preſbyopia
546 The remedy for preſbyopia
547. That a medium between ſhort and long ſightedneſs is beſt
548. In what manner we judge of the magnitude of objects
549. The force of the light and its effects
550. How the place of an object is eſtimated
551. Diſtance
552. How we perceive gibbous objects
553. In what manner we judge of the ſituation of the parts of objects
554. That the images of objects remain for a little time, even after the objects themſelves are remov'd
555. Various queſtions concerning viſion.

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556. That ſenſation then happens when a new thought ariſes in the mind by the percuſſion of a nerve
That that thought is not the image of the object affecting the nerve
That thence an arbitrary connexion ariſes between the changes produced in the nerves and the thoughts produced in the mind
Why, notwithſtanding this, what we perceive of this world is not falſe
557. What things are joined together while we think
558. That the changes produced by objects in the nerves remain a long time in their origin
The preſervation and order of theſe traces
559. Imagination, what it is
560. Memory
561. At what times of life the memory and imagination flouriſh, and when they decay
562. Thought and attention
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The ſprings of error
563. Soundneſs of judgment, on what it depends, and by what it is weakened
564. What ideas moſtly affect the will
565. The affections of the mind
Effects of the affections of the mind
566. The cauſes of theſe effects
567. That the paſſions of the mind are faithfully expreſſed in the countenance

Phyſiognomy, whence it ariſes
568. Conſent of parts, whence it ariſes
569. That the nature of the ſoul is different from the body
570. That the ſoul, however, is moſt cloſely connected with the body
571. That we have no occaſion to be aſhamed of our ignorance of the reaſon of this connexion
572. By what arguments chiefly thoſe are perſuaded who ſeek for the origin of all the motions and actions in the body from the ſoul
573. 576. Objections againſt that opinion
577. Watching
Sleep
578. Dreams
That with theſe, ſome voluntary motions are ſometimes conjoined
579. What actions continue to be carried on during ſleep
580 How the mechanical cauſe of ſleep is to be diſcovered
The phenomena of watching and ſleep
581. 584. What things contribute to ſleep, and what produce it
585. The proximate cauſe of ſleep
586. 587. That this is confirmed by the cauſes of watching, and what theſe cauſes are
588. That the ſeat of ſleep is not in the ventricles of the brain
Why the vital actions go on in the time of ſleep
589. The effects of ſleep
590. Various queſtions concerning the nature of ſleep.

Chap. XIX. MANDUCATION, SALIVA, and DEGLUTITION.

591. That moſt kinds of food ſtand in need of manducation
592. That therefore moſt animals are furniſhed with teeth
Their ſtructure in general
593. That mankind, on account of their diverſity of food, have different kinds of teeth
The inciſors
594. The canine teeth
595. The grinders
596. That the teeth are fixed in the jaw-bones
The various motions and articulation of the lower jaw
597. The levators of the jaw
The pterygoideus externus
598. How the jaw is depreſſed
599. The powers of the levator muſcles
The muſcles producing a lateral and circular motion of the jaw
600. The cheeks
The lips
The mouth
The ſituation and mobility of the tongue in the mouth
601. The liquor poured upon the aliments during maſtication
Its fountains
That the ductus inciſivus is blind
602. The ſaliva
603. The parotid gland
The gland called the acceſſory one
604. The maxillary one
The ſublingual one
605. That theſe, when compreſſed, pour out their liquor during the time of maſtication
Which compreſſion only produces the appetite
606. That the aliments are triturated with ſaliva and air during

ring the time of feeding
That thus they are rendered ſapid
That the volatile parts are thus reſorbed
607. The motion of the tongue for revolving the aliment from one part of the cavity of the mouth to another
608. That the tongue is directed by the os hyoides
The muſcles depreſſing the os hyoides
609. The muſcles raiſing the os hyoides
610. The muſcles of the cheeks and lips
611. The aliment being chewed is then collected by the tongue, and protruded towards the fauces
612. How the food is carried from the mouth into the fauces
How the entry into the larynx is cloſed
613. The pharynx
614. The muſcles dilating the pharynx
615. How we take care that no food falls into the larynx
The velum of the palate
The uvula
616. How the return of the aliment into the mouth is prevented
How the epiglottis and uvula are erected after they have been depreſſed
617. The powers which preſs the aliments downward by the pharynx
The action of the arytenoid muſcles
618. The mucus of the pharynx, and the various ſprings of it
619. The tonſils
The mucus of them exceedingly ropy
That the neighbouring parts are full of mucous organs
The more fluid mucus of the œſophagus
The veſſels of the tonſils, pharynx, and œſophagus
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622. The ſituation, figure, and bigneſs of the ſtomach
623. The viſcera in the neighbourhood of the ſtomach
624. The external membrane of the ſtomach
The firſt cellular coat
625. The muſcular coat of the ſtomach
The ligaments of the pylorus
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The nervous coat of the ſtomach
The third cellular coat
The villous coat
The valve of the pylorus
The pores of the villous coat
627. The arteries of the ſtomach
628. The diſtribution of the arteries through the coats of the ſtomach
629. The veins of the ſtomach
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813. The diſtribution of the ſmall arteries through the teſticle
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824. The animalcules of the ſemen
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828. The quantity of ſemen
That the ſemen comes from the teſticle into the ſeminal veſſels
829. The proſtate gland
Its liquor
829. * The three dilatations of the urethra; its various direction; its coats
[*Omitted by miſtake in its proper place*]
" 829. The urethra, though in general of a cylindric figure, is yet dilated into three pretty large cavities. The firſt is in the proſtate, about the ſeat of the *caput gallinaginis*; the other is in the bulb; and the third in the beginning of the glans. Its duct is generally horizontal at firſt; it then aſcends along the oſſa pubis; and, laſtly, in man it is pendulous, except during the time of venery. It is continued from the nervous coat of the bladder, and is covered inwardly with a very ſmooth cuticle, between which and the nervous coat is interpoſed a cellular texture."
830. The cavernous bodies of the urethra
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833. The teguments of the penis
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853. The age at which the menſes begin to flow
854. The phenomena of the menſes
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885. What can be more certainly known concerning this matter
886. The ſtate of the embryo before conception
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887. Objections from moles, of no weight
888. The change of the egg when brought into the uterus
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889. The contents of the egg at that time
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899. Whether there is no allantois in the human race
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907. That the motion of the heart accedes to this kind of embryo
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910. That the embryo is formed during its growth
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958. The cauſe of the deſtruction of the ſolid parts
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960. How the waſte of the cellular ſubſtance and moſt organic parts is repaired
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970. Decrepit old age
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FINIS.

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